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HISTORY OF THE STUDY OF ORE MINERALS*

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When faced with the problem of delivering a presidential address, it seems but natural to turn to the efforts of one's immediate predecessors in office in an attempt to get some inkling of what is expected in that line. Following this procedure, I was confronted with the brilliant speeches of the two busy B's, Bayley and Bowen, and felt somewhat discouraged as I knew I could not hope to emulate either the erudition of the one or the classical background of the other. However, a careful perusal of their addresses makes it sufficiently obvious that at least one aspect of mineralogical science, namely the subject I have chosen for my address, has been left virtually untouched. There seemed, therefore, little danger of any considerable amount of repetition, at least during the last three-year period.

As there has been a very extensive development within the field of ore mineral study during the last three or four decades, it seemed appropriate at this time to take stock of our knowledge and the important contributors to it. Any human historical document must be, in the very nature of things, somewhat incomplete. However, when an attempt is made to confine such a document within the narrow limits of a presidential address, it becomes quite impossible to give anything more than the high-lights, leaving the rest of the story to the highly-trained imagination of the intelligent audience. With this preamble, in the short time at my disposal, may I be permitted to give a brief outline of some of the developments in the study of ore minerals. Before I start please notice that I have said "some of the developments," and, if you are inclined to be critical over the almost certain omission of notable contributions, please note that in the preparation of this one historical effort there was compiled a reference list of over one hundred and seventy-five papers and text-books, of which over one hundred and fifty were summarized.

In any chronological recording of events it is always impossible to give the final word except in terms of contemporary progress, and it is always difficult to say just when the particular process of reasoning that led to the establishment of a new branch of any science may have had its inception. Perhaps however, as a convenient sort of spring-board that we may use before diving into the subject proper, we may cite the observations on meteorites of Baron von Widmanstätten in 1809. While the famous figures bearing his name, which were later noted on metals also, were not observed in the first instance on minerals and not under the microscope, nevertheless they must have been studied under reflected light from a polished surface and so may be considered as a sort of stepfather of this branch of our science. Although noted at this time by Widmanstätten, the first published mention of these figures was made in 1812 by K. A. Neumann (1812), who developed them on polished sections of the Elbogen meteorite by etching with nitric acid. Next we have Berzelius (1814) polishing a surface of pyrrhotite and noting by macroscopic methods the presence of another mineral, probably pentlandite, which cut across it in the form of narrow veinlets. But, although other investigators, such as Chladni (1819) and Von Schreibers (1820), continued the macroscopic study of meteorites, it was not until the time of Sorby, that any very substantial advance was made in this particular direction. Sorby, as you all know, was the first to develop the use of the petrographic microscope for the study of rock-forming minerals in thin sections. Inspired by this very notable contribution, this eminent investigator turned his attention also to the microscopic study of iron meteorites, using for this purpose polished sections of this extra-terrestrial material. A natural step was the use of this reflected-light method for the study of metals and alloys (1887), and so he was also largely responsible for the birth of the sister subject of metallography. But, while this method of studying polished surfaces under the microscope has been available since about 1865, it was not until twenty years later that it was applied to the study of ore minerals. At that time Baumhauer (1885) examined macroscopically polished sections of copper minerals from Chloride, New Mexico, using concentrated nitric and hydrochloric acids as etch reagents to differentiate the various minerals. The following year the same investigator (1886) applied this method to the study of smaltite-chloanthite ores from four German localities. From this time until the end of the last century there seems to have followed a fourteen-year period when this method was very little used, and interest in it during that time was kept alive only by the work of such scientists as Becke (1886), Drude (1888–1890), Weinschenk (1890), and Beijerinck (1897–1898), reference to which will be made later.

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With the start of the present century, however, interest seems to have been revived and progress has been rapid and continuous for the last thirty-eight years. An inevitable concomitant of this progress was the rapid diversification of interest and the development of different angles of attack. Once there was established the collaboration of the polished section and the microscope, many avenues of approach were opened up for the investigator in this field. When considering the best way to record the progress along these different avenues, your historian decided it would be more systematic and less confusing to explore each avenue in turn rather than to attempt a presentation of a composite picture in terms of contemporaneous development. If some of them appear to be short, seeming more like lanes than avenues, please remember this is probably due to the lack of interesting trees along the way, and don't blame it on the poor recorder. A review of the whole field of endeavor would be quite impossible in an address of this kind. It seemed possible nevertheless to select about twelve different angles of approach, which might be here listed, arranged for the most part in alphabetical order, the exceptions being the first of a more general character and the last of a specialized nature. They are as follows:

1. Studies of general methods employed.
2. Studies of abrasives and polishing methods.
3. Studies of chemical methods.
4. Studies of the electrical conductivity of ore minerals.
5. Studies of mill-products.
6. Studies of optical methods.
7. Studies of physical properties of ore minerals.
8. Studies in quantitative macroscopic and microscopic analysis.
9. Studies in the synthesis of ore minerals.
10. Studies in technique.
11. Studies by *x*-ray methods.
12. Studies in special fields.

General Methods

Taking these up in the order mentioned it is very interesting and instructive to note, first, the many records of achievement from 1906 to 1931 in the general field of ore-mineral study. During this period the science owes a great debt to investigators in many countries. There might be mentioned in this connection the names of Orcel (1925–1928). Legraye (1925–1927) and Legrange (1927) in France; of Berg (1915), Granigg (1915–1920), Hummell (1925), Ramdohr (1924) and Schneiderhöhn (1920–1931) in Germany and Austria; and of Campbell (1906), Ray (1914), Bruce (1914) and Fairbanks (1928) on this continent. As a result of the efforts of these and other investigators substantial progress has been made in the direction of improvement of the general methods employed for the determination of ore minerals. The only discordant note in this symphony of progress has been the invention of a number of unsatisfactory aliases as titles for this branch of mineralogy. Still the author has to confess that, while he does not like any of the titles so far conferred on it, namely mineralography, mineragraphy and chalcography, he has not himself been able to find one that measures up to the needs of the case. Text-books and reference volumes on the subject were written during this period by Murdoch (1916), Davy and Farnham (1920), Van der Veen (1924), Farnham (1931), Short (1931), Ramdohr and Schneiderhöhn (1931), and we are especially indebted to these scientists for their valuable contributions in this direction.

Abrasives and Polishing Methods

Let us now consider the development in methods of polishing. As the efficiency and accuracy of this branch of mineralogical science was largely dependent on the maximum degree of polish of its working sections, it was but natural that investigation looking towards the betterment of polishing methods should have attracted many observers. At the present time it seems a far cry from the crude methods of hand-polishing employed at the beginning of this century to the highly specialized machine processes of the present time, but the one has led very naturally to the other through intermediate steps of varying degree. As examples of the earlier hand-polishing methods one might quote the observations of such workers as Campbell and Knight (1906–1907) and Ellsworth (1916). These methods were soon supplanted by machine operation with finer and finer abrasives used in the various stages of polishing, and notable contributions were made by such workers as Whitehead (1917) and Short (1926). Probably the greatest contribution in this part of the field was made by Vanderwilt (1928), who, departing largely from the old idea of rolling-grain abrasion, used the principle of fixed-grain abrasion in lead and copper laps. Contemporaneous with this development, or perhaps preceding it, we have the mounting of the mineral specimen in a mounting medium, first of sealing wax backed with plaster of Paris, later of bakelite made under heat and pressure. Still more modern practice as outlined by Dunn (1937) of the Geological Survey of India and others, mentions the successful use of cellulose acetate in place of the bakelite. Following along with these two developments we have the progress in the direction of abrasives used in the polishing process. Where formerly coarse carborundum powders were used, the common practice of to-day includes a very narrow range of abrasives from 5 micron alundum powder to the finest tin oxide or magnesia flour. This has brought with it the slight disadvantage of a longer period of operation, but there seems no reason to suppose that more intensive investigation in this part of the field may not again make possible the curtailment of the time required for polishing.

Chemical Methods

Of all the avenues of approach followed by investigators of ores, none has been more consistently followed than the avenue of microchemical research. From the time of Becke (1886), when such etch reagents as nitric and hydrochloric acids and potassium chlorate were used to differentiate minerals of the magnetite group, until the present day, notable contributions to our knowledge of this phase of the subject have been made by scientific workers. These contributions have taken the form either of a multiplication of etch reagents, or the development of new methods of application. In the former, two schools of thought soon emerged, the one represented by such eminent foreign scientists as Van der Veen (1924), Ramdohr and Schneiderhöhn (1931), using many reagents, each one adapted to the differentiation of one or a few minerals, and the other followed by such writers as Murdoch (1916), Davy and Farnham (1920), Farnham (1931) and Short (1931), using a limited number of reagents with more general application to a whole host of ore minerals. In the development of new methods of application there must be mentioned the staining methods of Granigg (1915–1920), Head and Crawford (1929) and Gaudin (1935), the electrochemical and photochemical methods of McKinstry (1927), the investigations of Osborne (1931) into the relative merits of the immersion and drop methods of applying reagents, the research of Fraser and Dreyer (1937) into the role played by interfering ions and the important contribution by Galopin, Geysin, Gutzeit, Hillier and Wenger (1933–1936) of the "á la touche" method, whereby the minerals are attacked by a solvent absorbed in a gelatin paper, which is later treated by reagents. These should be considered as important milestones in the path of progress. The text-books of Chamot (1915) and Behrens-Kley (1921), and that portion of Short's text-book (1931, pp. 115–201) dealing with this phase of the subject should also receive honorable mention in this connection.

Electrical Conductivity

Still another attractive angle of approach lay in the study of the electrical conductivity of ore minerals. The earlier investigations in this direction, such as those of Beijerinck (1897–1898), Koenigsberger and Reichenheim (1906), Borgström and Dannholm (1916), Wartman, Braun, Dufet, and many others tested this property either on macroscopic specimens or on mineral powders, while later researches by such workers as Davy and Farnham (1920), Kerr and Cabeen (1925), and Harvey (1928) were carried out on polished sections under the microscope. Their observations, although covering a wide range of mineral specimens, were made chiefly on sulphide, arsenide, and oxide compounds and seemed to indicate very clearly not only that the conductivity of a natural opaque mineral is not constant, but that it may show variations of from hundreds to even millions of per cent. The chief factors causing these wide variations were considered to be the presence of impurities, non-uniform temperature, change in orientation, variation in size of mineral crystals, destruction of the crystal lattice by heating, grinding, fracturing, or oxidation, and exposure to light. As a by-product of these investigations we have the use by McKinstry (1927, pp. 671–673) and others, of a low-voltage current to increase the susceptibility of certain ore minerals to etch reagents.

Mill-products

While most students of ore minerals were content to confine their investigations to polished sections of solid mineral specimens, a great deal of research was also carried out in the related fields of ore dressing and milling. The earlier efforts in this part of the field for the most part were confined to the study of these fragmental products in the rough state. In this connection there might be cited the investigations of Head (1925), and of Coghill and Bonardi (1919). The use by the latter two workers of a binocular microscope and a camera lucida for sketching the outlines of the mineral grains before counting the particles, represents an application in this direction of methods used much earlier by Sollas (1891) and Joly (1903). Investigation in this part of the field was rendered more efficient in later years not only by the use of mounting media similar to those used for solid specimens, but also by notable improvements in methods of polishing such fragmental material. At first, as with the solid mineral specimens, ordinary sealing wax poured into a rectangular brass container was used as the mounting medium. In these mounts, sometimes the mill-products were mixed all through the wax, sometimes they were confined within the narrower limits of a brass or copper ring placed within the larger container. These mounts were soon found to be unsatisfactory, particularly during the warm summer months, as the wax had a strong tendency to flow. With the discovery of the resin materials, redmanol and bakelite, vastly superior mounting media were uncovered and found a wide application. Outstanding contributions in this field were made by Head and Slavin (1930) and by Fairbanks (1924). For such cases as require observation of those parts of the mineral fragment other than that exposed at the polished surface, transparent mounts of "lucite" or "pontalite," manufactured by the Dupont Chemical Co., have been used by Haycock and others. Transparent media have also been developed by the Bakelite Corporation and by the French Ivory Co. For those who are interested in this phase of the subject, these and other mounting products are mentioned in some detail in the "Handbook of Chemistry and Physics," published by the Chemical Rubber Publishing Co. of Cleveland. It is not the purpose of this article even to mention the many complicated processes involved in all the phases of milling practice. However two recent developments, having to do with the classifying of products below 200 mesh in size, and the assembling of such fine materials in sufficient quantities for microscopic analysis, impinge very strongly on the field of mineralogical research and so must receive at least a passing mention. With the devising of the Haultain (1937) infrasizer and superpanner it is now possible to examine even those constituents of the ore that are to be found only in minute quantities. The far-reaching effects of the investigation of such mill-products needs no emphasis at this time and it seems certain that in the near future it will find an even wider application than heretofore.

Optical Methods

For many years optical methods of approach have engaged the attention of research workers in many parts of the world. For the most part these have followed three main directions, namely, investigation of maximum reflectivity and other optical constants, determination of anisotropism in polarized light, and spectroscopic research. Of these the determination of optical constants of ore minerals seems to have attracted many workers. This type of investigation was probably started by Drude (1888) when he obtained for stibnite such optical constants as the indices of refraction and coefficients of absorption, using a spectrometer equipped with rotatable nicols in the collimator and telescope tubes. Two years later the same worker determined the optical constants of various metals and alloys (1890), using Kundt's method of diverting a beam of light through a metal prism. Drudes' methods were also employed by Forsterling (1908) to determine the reflectivity and other optical constants of hematite. Substantial advance in this part of the field was not attained until the development of photometric methods for determining reflectivity, first by Orcel (1927) and Schneiderhöhn (1928), later by Frick (1930) and Moses (1936). The application of these methods has made possible the precise determination of the reflecting power of various ore minerals and has placed another valuable tool in the hands of workers in the field of ore mineral study. Observations on the anisotropism of ore minerals seem to have been started early in this century by Koenigsberger (1908) who used a Savart plate, a plate of known refractive index, a reflecting prism and a contrast biplate of smoky quartz. His work was followed by that of F. E. Wright (1920), who developed methods for determining the degree of anisotropism involving the use either of a special cleavage plate of calcite or of two biprisms of quartz, called the bi-quartz wedge plate. Other workers in this field include Glaser (1924), Orcel (1928), Sampson (1923, 1929) and Goranson (1933). Spectrographic studies of the ore minerals seem to have been much less popular than the other two approaches from the physical side. The names of but five workers in this part of the field have come to the writer's attention, namely Schneiderhöhn (1929), Claussen (1934), Berthelot and Orcel (1930) and Harcourt (1937). Of these Schneiderhöhn conducted spectrographic analyses on the platinum ores of the Bushveld Complex, Claussen did similar work on galena, sphalerite, and pyrite from many localities, and Harcourt used this method to distinguish enargite and famatinite. No doubt I will be reminded later of the names of other workers in this field, but at present these are the only five that have come to my notice. To complete the picture on the optical side, mention must be made of the extensive observations of Guild (1917), Schneiderhöhn (1922 B), McKinstry (1927) and Stephens (1931) on the effect of strong light sources on silver minerals, and also of the investigations of Myers (1924) on the advantages of oblique illumination.

Physical Properties

We shall next turn our attention to a very brief consideration of studies in the field of physical properties. While most investigators in the field of ore mineral study have relegated to a place of secondary importance observation of such physical properties as hardness, color, and streak, a few workers have studied these properties intensively. Although most workers have made use of hardness as a means of identifying the ore minerals, the determination of this property has been rather imperfect in most cases. Some form of steel needle or other simple hardness-tester, in the opinion of many workers, has been amply sufficient for the purpose. Nevertheless, attempts have been made by some workers to determine this property more accurately. In 1923 Bierbaum made a study of the hardness of bearing metals, using an instrument, called a microcharacter, for measuring the width of the cut. This instrument, which was later used by Hodge and McKay (1934) for determining the microhardness of minerals, consists essentially of a tiny diamond under which the mineral to be tested is moved, a constant load being maintained by a small weight mounted on a lever-spring system. The width of the cut, called the microcut, produced by this device, is measured by means of a filar micrometer eyepiece. Hodge and McKay determined the microhardness of nine members of Mohs' scale of hardness to be as follows: talc 1, gypsum 11, calcite 129, fluorite 143, apatite 517, orthoclase 975, quartz 2700, topaz 3420, corundum 5300. Talmage (1925 B), another worker in this field, used a scratch-sclerometer with a diamond blade substituted for the original steel needle and established a seven-way classification of hardness. This method has now become standard practice in many scientific laboratories.

The same worker (1925 A) has conducted research on the diagnostic value of color in identifying ore minerals. By using either a comparison microscope or two microscopes equipped with a comparison ocular, and with the color contrasts intensified by the use of color-screens, he was able to establish the fact that the absolute color value of any opaque mineral is constant. Still another worker, Gaubert (1923), investigated such physical properties as form, transparency and streak, the last mentioned property being studied either on a glass slide or on an unpolished quartz plate.

Quantitative Analysis

Another attractive avenue of investigation followed by many during the last ninety years has led in the direction of quantitative macroscopic and microscopic analysis. While it is true that most of the efforts in this direction have been confined to determining the quantitative relations of the rock-forming minerals, some investigators at least have turned their attention towards a quantitative determination of the opaque minerals in ores. Time does not permit of a detailed account of all the research conducted in the field of quantitative study, but mention must be made in passing of the notable contributions of such pioneers as Delesse (1848) and Rosiwal (1898), who first enunciated the important principle that the volumetric might be directly related to the areal or even the lineal proportions, provided enough area or enough lineal measurement was included to take care of the third dimension. Most of their observations were made on hand-specimens of coarse-grained rocks, although Rosiwal made some of his measurements under the microscope. In later times, for the development of methods involving the use of the planimeter and of the integrating stage, we are indebted to such workers as Johannsen (1919), Shand (1914) and Wentworth (1923). The latter method, although necessitating the purchase of a costly accessory to the microscope, is at present in common use in those laboratories where a considerable number of quantitative microscopic analyses is carried out each year. All of the above-mentioned workers directed their attention towards a determination of the quantitative relations of the rock-forming minerals. Their methods however have also been used by many scientists in a study of similar relations of ore minerals. R. E. Head (1921) has applied them to a quantitative study of the copper and iron minerals in a porphyry ore, while the writer (1930 A) has been privileged to test some of these older methods, to devise slight variations of the old Delesse and Rosiwal methods, and to apply these methods in the direction of a quantitative determination of the ore minerals at Cobalt, Ontario (1930 B).

Mineral Synthesis

An interesting angle of attack which, more especially in recent times, has attracted several workers is that of mineral synthesis. This method seems to have been employed first by Weinschenk (1890) who was successful in synthesizing many sulphide minerals. Later this method was used by Beutell and Lorenz (1916) as a means of explaining the variable composition of such arsenide minerals as smaltite, chloanthite, skutterudite and loellingite. In more recent times it has been extensively employed by such workers as Ramdohr (1926), Schwartz (1928–1932), Gaudin and McGlashan (1938) to explain the intimate and complex intergrowths of iron, copper, and silver minerals. In this modern practice sometimes the minerals are synthesized from chemical salts, sometimes the natural mineral intergrowths are subjected to heat treatment and the effects noted with rapid quenching and with slow cooling. Remarkable duplications of natural intergrowths have been attained by the latter method in many instances. The preparation of pure synthetic minerals for polished surface study is also suggested by Schwartz (1932) as an aid in evaluating the etch reactions of the ore minerals.

Technique

As a very valuable by-product of the progress along the main avenues of approach, there has been developed an improvement in technique of manipulation that has proved of material assistance to research workers in this field. To mention but a few of these developments, there is the method used by Short (1926) and others, of impregnating friable ores with balsam or bakelite, that devised by Donnay (1930) for using reflected light on thin sections by polishing the rock chip first and then grinding to the required thickness for thin sections, the method of Orcel (1925) for determining the rotation of the plane of polarization, the use by Osborne (1928) of glass cylinders to confine the etching liquid to a small portion of the polished surface, and the use by Schneiderhöhn (Wagner 1929), Haycock (1931), Harcourt (1937) and others of a small dental drill for obtaining small samples for microchemical analysis.

X-ray Methods

Investigation by x-ray methods, which has been used extensively to explore the atomic structure of rock-forming minerals, up to the present time has not been used by many workers for determining the structure of ore minerals. Notable contributions have been made in this direction by Wyckoff (1921) who investigated the crystal structure of alabandite, by Kerr (1924) who found the powder method best adapted to the study of ore minerals, by Ramsdell (1925) who checked the isomorphism of various groups of sulphides by this method, and by Frebold (1926) and Waldo (1935) who used this method for the identification of iron and copper minerals, respectively. The possibilities of further exploration along this main avenue are indeed great and it seems certain that earnest collaboration in the future between x-ray workers and microscopists will be the greatest factor in adding to our knowledge of ore minerals.

Special Fields

In the very broad field of studies of special ores, mention can only be made of a few striking examples. One of the most popular of these special fields is the study of the common association of cobalt-nickel-silver ores, as shown by the classic localities in Germany and Cobalt, Ontario. The ores from the German districts have been studied intensively for the past fifty years while those from Cobalt have been the subject of scientific scrutiny for over thirty years. The names of such investigators as Baumhauer (1886), Beutell (1916), Flörke (1922) and Oftedal (1928) are prominently connected with the study of the German ores, while Campbell and Knight (1906), Ellsworth (1916), Bastin (1917), Schlossmacher (1921) and Thomson (1930 B), carried out observations on the ores from Cobalt. A more general study of the three common associations for silver ores, namely silver-lead-zinc, copper-silver, and cobalt-nickel-silver, was made by Guild (1917), while Emmons, Stockwell and Jones (1926) conducted a special study by x-ray methods of the two forms of silver sulphide.

Another field of special study has to do with the nickel ores at Sudbury Ontario, and other localities. In this direction such observers as Campbell and Knight (1907), Lindgren and Davy (1924), Short and Shannon (1930), and Buddington (1924) have carried out investigations on pentlandite and on the rarer nickel minerals. For over fifty years copper ores have been studied in polished section under the microscope and the names of such investigators as Baumhauer (1885), Graton and Murdoch (1913), Borgström (1916), McLaughlin (1917), Ramdohr (1928) and Fackert (1928) might be cited in this connection.

In the study of iron ores such observers as Hussak (1904), Brunton (1913), Singewald (1913 A & B), Bayley (1923) and Watson (1922) have confined their attention to interesting microstructures to be found in the magnetite-ilmenite, magnetite-rutile, and magnetite-hematite associations, while Schneiderhöhn (1920 B), Sosman and Hostetter (1918), and Wagner (1928) conducted investigations either on zoned hematites or on iron ores in general. Little work has been done on ores of platinum but Aminoff and Parsons (1928) studied by x-ray methods the crystal structure of sperrylite, and Wagner (1929) published an exhaustive treatise on the "Platinum Deposits and Mines of South Africa." In this connection it should be mentioned that the microscopic study of the South African platinum ores was carried out by Schneiderhöhn, this being included in Wagner's book.

Studies of the manganese ores have also attracted the attention of scientists in many parts of the world. The names of Déribéré, Hermann, Siegert, Esparseil, Maggiore, and Gavasheli might be mentioned in this connection. Special reference should also be made to the work of Cooke, Howes, Warren and Emery (1913) on psilomelane and manganite, and to the work of Thiel (1924) on manganese minerals in general. Another special field of more than common interest is that of mineral intergrowths. The significance of these intergrowths has been sought after by such workers as Rogers (1916), Uglow (1922), Newhouse (1927–1931), Grigoriev (1928), Gruner (1929) and Schwartz (1928–1931). As mentioned in an earlier part of this paper, some of these intergrowths at least, which may have originated from unmixing or replacement, have been successfully reproduced by synthetic laboratory methods.

In concluding our discussion of advances made along these different avenues, it would be quite misleading to omit special mention of those investigators of ores whose published works lie rather in the field of economic geology than in the study of ore minerals. For the most part these scientists are to be found in academic surroundings and, while in a few cases they have left some published records of their research activities in the direction of ore mineral study, their main contribution has been in stimulating an interest in ore minerals on the part of their colleagues and advanced students and assisting them in their various forms of research. There are many of these on this continent. The writer has knowledge of and has had personal contact with two outstanding examples of this type of academic figure. They are Professor Graton of Harvard University and Professor Lindgren of Massachusetts Institute of Technology. The writer wishes at this time to pay tribute to the inspiration and encouragement that, in common with many others, he has received at their hands. There are many other quiet workers of the same type who ask for no other reward for their efforts than the advancement of this science through the efforts of others. To them also all students of ore minerals owe a great debt of gratitude.

Future Development

And now that we have explored some of the avenues of approach which have been followed by students of ore minerals, what can we say of the possibilities of future development in this branch of mineralogical science? Without going outside the avenues already mentioned, which of these methods of approach seems to promise the most productive results? While admitting the strong possibility of further improvement in the direction of general methods, polishing methods, technique and the study of physical properties, it seems likely that progress in the next decade or two will be carried out in the directions of improvement of chemical, electrical, and optical methods, of further study of the structure of ore minerals using the powerful tools of mineral synthesis and *x*-ray investigation in collaboration with microscopic research, and in the more intensive study of those fragmental materials which are to be found either in placer deposits or in the products of the mining-mill. It seems probable, also, that the attention of students in this field will be diverted more and more to the study of special suites of ores in the hope that much more light may be shed not only on the qualitative but also on the quantitative relations of the ore minerals present.

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PETROGRAPHY OF SOME SOUTH VICTORIA LAND ROCKS

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ABSTRACT

A petrographic quantitative study has been made of the mineral composition of certain igneous intrusive rocks of South Victoria Land, Antarctica, and comparisons made between these rocks and those examined from other Antarctic lands.

INTRODUCTION

Forty-five specimens of Antarctic rocks and minerals have been added recently to the collections of the University of Michigan[1] through the courtesy of Dr. W. Campbell Smith of the British Museum. These samples were collected by Mr. Frank Debenham and Mr. R. E. Priestley, of the British Antarctic *Terra Nova* Expedition, 1910–13, in the vicinity of Granite Harbour, approximately Latitude 77° South, Longitude 162° East, and Terra Nova Bay, approximately Latitude 75° South, Longitude 164° East, South Victoria Land (Fig. 1).

Fourteen specimens are referred to, or have been reported on briefly, by Smith.[2] Of these, quantitative mineralogical data for five (D11G, D56G, D85G, D104G and 1966) are recorded in this paper. Three other reports[3,4,5] of the *Terra Nova* Expedition were helpful in the compilation of the results of this research. Still other references on the petrography of South Victoria Land rocks are those of Benson,[6] Prior,[7] Rastall and Priestley,[8] Schetelig,[9] and Stewart.[10]

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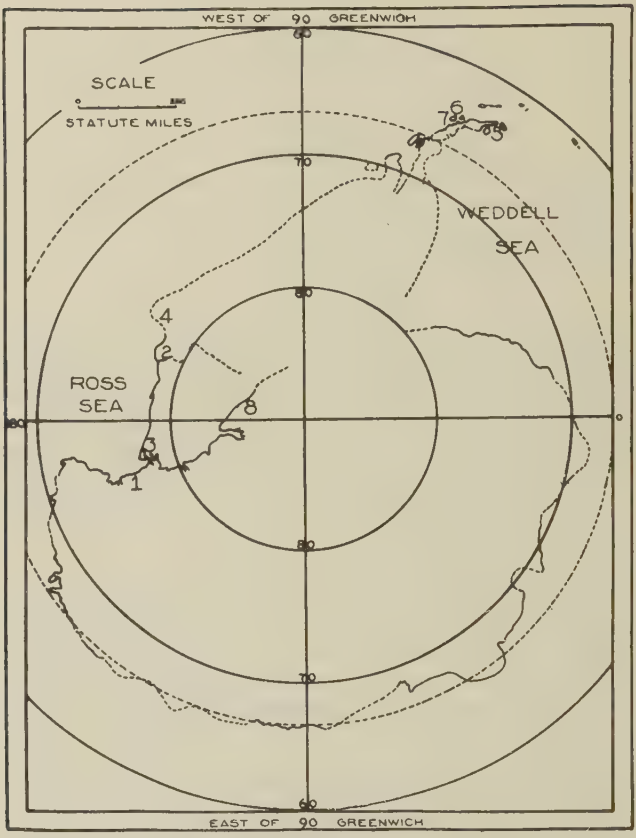

FIG. 1. Sketch map of Antarctica showing the distribution of collection localities.

1. Granite Harbour and Terra Nova Bay, South Victoria Land.
2. Rockefeller Mountains, King Edward VII Land.
3. Ross Island, South Victoria Land.
4. Edsel Ford Range, Marie Byrd Land.
5. Hope Bay, Louis Philippe Land, West Antarctica.
6. Localities of the Expédition Antarctique Française and the Expédition Antarctique Belge, West Antarctica.
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TABLE 1. MINERALOGICAL COMPOSITION OF SOME ROCKS FROM SOUTH VICTORIA LAND

Mineral	Specimen																		
	1383*	1600*	1422	1648	D11G	1568	1573	1966	1592	D71G*	1424	D104G	D56G*	D21G	1328	1346	1722	1740	D85G
Quartz	36.62	32.46	30.90	30.48	29.18	28.73	27.10	18.59	18.26	14.04	12.75	5.91	0.22	p	—	63.63	36.34	30.19	19.00
K-feldspar	47.53	29.06	37.55	p	30.44	30.01	0.42	32.69	16.60	p	—	5.71	74.13	67.20	—	—	26.57	18.69	—
Oligoclase	—	33.38	24.73	65.16	34.33	—	51.08	36.01	36.66	58.73	—	46.31		12.01	—	—	—	25.67	—
Albite	3.68	—	—	—	—	36.11	—	—	—	—	—	—	—	—	—	—	—	—	—
Andesine	—	—	—	—	—	—	—	—	—	—	42.12	—	—	—	44.32	22.20	—	—	—
Plagioclase	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	20.60	—	—
Biotite, chlorite	p	4.63	4.48	3.97	6.05	3.54	20.64	12.49	20.84	2.87	17.55	39.70	21.42	—	15.86	12.25	15.55	23.76	—
Green hornblende	—	–	—			—			3.56	22.82	26.17			—	36.07	—	—	—	—
Diopside	—	—	—	—	—	—	—	—	—	—	p	—	—	3.94	—	—	—	—	49.34
Wollastonite	—	—	—	—	—	—	—	—	—	—	—	—	—	5.48	—	—	—	—	—
Vesuvianite	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	3.27
Mizzonite	—	—	—	—	—	—	—	—	—	—	—	—	—	6.56	—	—	—	—	—
Prehnite (?)	—	—	—	—	—	—	—	—	—	—	—	—	p	—	—	—	—	—	—
Muscovite	10.40	p	p	p	p	p	p	p	—	p	p	p	p	—	—	p	p	p	—
Apatite	—	p	p	p	p	p	p	p	p	p	p	p	p	p	p	—	p	p	—
Zircon	—	p	p	p	p	p	p	p	p	p	p	—	p	—	p	p	p	p	—
Iron "ores"	p	p	p	p	p	p	p	p	p	p	p	p	p	p	p	p	p	p	p
Sphene	—	p	—	—	p	—	p	—	3.23	p	p	p	p	p	p	—	p	p	—
Epidote	—	p	p	—	p	—	—	—	p	—	—	p	p	—	—	p	p	—	—
Zoisite	—	—	—	p	—	—	—	—	p	p	p	—	—	—	p	—	—	—	—
Cassiterite	p	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Tourmaline	1.76	—	p	—	—	p	—	—	—	—	—	—	—	—	—	—	?	—	—
Topaz		—	—	—	—	—	—	—	—	—	—	—	—	—	—	p	—	—	—
Rutile (?) needles	—	p	p	—	—	p	p	p	p	p	p	—	—	—	—	p	p	p	p
Apatite (?) needles	p	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	p
Allanite (?)	—	p	—	—	p	—	—	—	p	p	—	—	—	—	—	—	—	—	—
Calcite	—	—	p	—	—	—	p	p	—	—	p	—	p	4.81	—	—	—	p	28.39
Leucoxene	—	—	—	—	—	—	—	—	—	—	p	—	—	—	—	p	—	—	—
Kaolin	p	—	p	p	p	p	p	p	p	p	—	p	p	p	—	p	p	p	—
Sericite	—	—	p	p	p	p	p	p	p	p	p	p	p	—	—	p	p	p	—
Accessories	—	0.46	2.34	0.39	—	1.61	0.77	0.21	0.86	1.52	1.41	2.37	4.22	—	3.75	1.92	0.93	1.69	—
	99.99	99.99	100.00	100.00	100.00	100.00	100.01	99.99	100.01	99.98	100.00	100.00	99.99	100.00	100.00	100.00	99.99	100.00	100.00

* Average of two sections.

1383. Kalialaskite. Terra Nova Bay.
1600. Leucoadamellite with angular fragments of microdiorite. Vegetation Island, Terra Nova Bay.
1422. Leucoadamellite. Erratic. Northern Foothills, Terra Nova Bay.
1648. Leucotonalite. Erratic. Boomerang-Campbell Moraine, Terra Nova Bay.
D11G. Adamellite. Devil's Punchbowl, Granite Harbour.
1568. Leuco-sodaclase-adamellite. Erratic. Hell's Gate Moraine, Terra Nova Bay.
1573. Tonalite. Erratic. Hell's Gate Moraine, Terra Nova Bay.
1966. Adamellite. Erratic. Hell's Gate Moraine, Terra Nova Bay
1592. Monzotonalite. Vegetation Island, Terra Nova Bay.
D71G. Tonalite. Cape Geology, Granite Harbour.
1424. Tonalite. Northern Foothills, Terra Nova Bay.
D104G. Monzotonalite. In talus below Devil's Thumb, Devil's Punchbowl, Granite Harbour.
D56G. Syenodiorite. Talus slope of Discovery Bluff, Granite Harbour.
D21G. Syenite. Marble Dike, The Flatiron, Granite Harbour.
1328. Meladiorite. Erratic. Priestley Glacier (?), Terra Nova Bay.
1346. Tonalite gneiss. Erratic. Evans Coves, Terra Nova Bay.
1722. Porphyritic adamellite gneiss. Erratic. Eastern Moraine, Corner Glacier, Terra Nova Bay.
1740. Adamellite gneiss. Erratic. Eastern Moraine, Corner Glacier, Terra Nova Bay.
D85G. Contact rock. Marble Dike, The Flatiron, Granite Harbour.

Twenty-seven of the specimens represent igneous rocks, eight are sedimentary, eight metamorphic, and two are minerals. Twenty-two of these specimens are labeled erratics. Forty-four thin sections have been examined and twenty-three quantitative mineralogical analyses have been made with the improved Wentworth recording micrometer. An aggregate distance of some 51,000 units was measured in traversing each section, an average of seventeen times. Quantitative results from thin sections of fifteen igneous and four metamorphic rocks are recorded in Table 1.

Acknowledgments

Grateful acknowledgments are due to Professors Stanard G. Bergquist, William H. Hobbs, Ralph C. Huston and Dr. W. Campbell Smith for their interest shown in this investigation. Professor F. Alton Wade kindly loaned the author 102 thin sections of rocks collected by the Second Byrd Antarctic Expedition, 1933–35, for comparative studies. A grant from the Patent Fund, Michigan State College, has made this research possible.

Characteristics of the Rocks

The fifteen intrusive rocks vary in composition from kalialaskite to meladiorite. The metamorphic rocks include three gneisses and one contact rock. The presence of cassiterite in small quantities in sections of specimen 1383, a kalialaskite, is of interest because of the scarcity of references to metallic minerals in Antarctic rocks. Cassiterite (?) has been previously noted by the author in acid intrusives from the Rockefeller Mountains, King Edward VII Land.

Antiperthite, small patches of K-feldspar in acid plagioclase, is recorded in sections 1568, 1573, 1722 and 1966. Strain shadows are observed in the quartz of six sections, and bent plagioclase twinning lamellae in eight sections of the intrusives. This apparent characteristic of some South Victoria Land basement intrusive rocks has been referred to by Mawson,[11] Prior,[12] Smith,[13] and Woolnough.[14]

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[11] Mawson, D., Petrology of rock collections from the mainland of South Victoria Land. Contributions to the palaeontology and petrology of South Victoria Land: British Antarctic Expedition, 1907–9, under the Command of Sir E. H. Shackleton, *Reports of Scientific Investigations, Geology*, Vol. II, Part XIII, 201–234 (1916).

[12] Prior, G. T., *op. cit.*, 126.

[13] Smith, W. Campbell, *op. cit.*, 169.

[14] Woolnough, W. G., Petrological notes on some erratics collected at Cape Royds. Contributions to the palaeontology and petrology of South Victoria Land: British Antarctic Expedition, 1907–9, under the command of Sir E. H. Shackleton, *Reports of Scientific Expeditions, Geology*, Vol. II, Part XI, 169–188 (1916).

In ten intrusive specimens zoning of the plagioclase feldspars is apparent. In eleven, micrographic intergrowths of quartz and feldspar are recorded, and in seven sections both zoned plagioclase and micrographic intergrowths occur. Reference to such an association is made by Woolnough[15] in a description of a quartz diorite erratic collected at Cape Royds, Ross Island, South Victoria Land. In a publication by Mawson[16] the association of zoned plagioclase and micrographic intergrowths is not mentioned in the study of rocks collected at Cape Irizar and certain other localities on the mainland of South Victoria Land.

Discussion

According to Nordenskjöld,[17] the plagioclase feldspars of the intrusives of the Hope Bay area, Louis Philippe Land, West Antarctica, exhibit zoning, and at times micrographic intergrowths of quartz and orthoclase. In a discussion,[18] resulting from a study of 107 rocks collected by Nordenskjöld's Swedish Antarctic Expedition, 1901–03, this occurrence was noted in certain intrusive rocks, and the occurrence of fragments of micrographic intergrowths in certain sedimentary rocks, most probably derived from the igneous rocks, was recorded. The studies of Gourdon[19] indicate a great similarity between the intrusive rocks collected by the Expédition Antarctique Française, the Swedish Antarctic Expedition and the Expédition Antarctique Belge,[20,21] all from West Antarctica.

Wade,[22] in referring to the intrusives of the Edsel Ford Range, remarks: "The eruptives of northwest Marie Byrd Land are high in sodium and potassium and are in this respect analogous to those of East Antarctica. However, the presence of zoned plagioclase in many of the intrusives suggests a relationship with rocks of West Antarctica." A preliminary examination of Wade's thin sections of thirty-six acid intrusives from northwest Marie Byrd Land indicates that some seventy-five per cent contain zoned plagioclase feldspars, thirty-five per cent micrographic intergrowths, and approximately thirty-five per cent exhibit both zoned plagioclase and micrographic intergrowths.

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[15] Woolnough, W. G., *op. cit.*, 173.

[16] Mawson, D., *op. cit.*,

[17] Nordenskjöld, Otto, Petrographische Untersuchungen aus dem westantarktischen Gebiete: *Upsala Univ. Geol. Inst. Bull.*, 1902–1903, **6,** 237 (1905).

[18] Stewart, Duncan, Jr., Petrography of some rocks from the South Orkney Islands and the Antarctic Archipelago: *Am. Mineral.*, **22,** 186 (1937).

[19] Gourdon, E., Géographie Physique.—Glaciologie.—Pétrographie des Régions visitées par l'Expédition Antarctique Française commandée par le Dr. Charcot (1903-05), p. 205, Paris (1908).

[20] Pelikan, A., Géologie, Petrographische Untersuchung der Gesteinsproben: Expédition Antarctique Belge, Résultats du Voyage du S.Y. Belgica en 1897–1898–1899 sous, le commandement de A. de Gerlache de Gomery, *Rapports Scientifiques*, Theil I, 49 pp. Anvers (1909).

[21] Sistek, Dragomir, *Ibid.*, Theil II, 29 pp. (1912).

[22] Wade, F. A., Petrologic and structural relations of the Edsel Ford Range, Marie Byrd Land, to other Antarctic mountains: *Bull. Geol. Soc. Amer.*, **48,** 1394 (1937).

The examination of the *Terra Nova* rocks shows that there is some petrographical similarity between certain South Victoria Land, Marie Byrd Land and West Antarctica specimens, inasmuch as there are zoned plagioclase feldspars associated with micrographic intergrowths in a number of the intrusives.

Schetelig,[23] after a comparative study of granite, diorite and granodiorite from West Antarctica and Scott's Nunatak, King Edward VII Land, concluded that the rocks of the two regions are not similar. Bodman[24] examined rocks from Scott's Nunatak, King Edward VII Land, and Mount Betty, Queen Maud Mountains, South Victoria Land, and found that they possessed characteristics different from those of the rocks of West Antarctica.

After comparative studies of Gould's[25] specimens from King Edward VII Land with specimens from the Queen Maud Mountains of South Victoria Land and with rocks collected by the Expédition Antarctique Française, 1903–05, in West Antarctica, the author[26] concluded that the rocks of the Rockefeller Mountains have close affinities with the high sodium- and potassium-bearing rocks of East Antarctica, and show little affinity with the high calcium-, magnesium-, and iron-bearing rocks of the Andes of South America and West Antarctica. The rocks of the Rockefeller Mountains do not exhibit zoned plagioclase feldspars in thin section, and moreover, the feldspars of the specimens from the Queen Maud Mountains, described by Stewart,[27] lack zonary banding.

CONCLUSIONS

It is suggested that the intrusives of West Antarctica, high in calcium, magnesium and iron, and possessing petrographical similarities, as zoning of the plagioclase feldspars and having affinities with the rocks of the Andes of South America, be placed in a petrographic province; that the intrusives of the Edsel Ford Range, northwest Marie Byrd Land, and certain of those of South Victoria Land, high in the alkalies and possessing some petrographical characteristics of West Antarctica rocks, as zoned feldspars, be placed in a second petrographic province; and, that intrusives of the Queen Maud Mountains, South Victoria Land, and those of the Rockefeller Mountains, King Edward VII Land, high in the alkalies, but lacking in the zonary banding of the feldspars, be placed in a third petrographic province.

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[23] Schetelig, J., *op. cit.*

[24] Bodman, Gösta, Petrographische Studien über einige antarktische gesteine: Wissenschaftliche Ergebnisse der schwedischen Südpolar-Expedition, 1901–1903, *Geologie und Palaontologie,* Band 3, Lieferung 15, 76–79, Stockholm (1916).

[25] Gould, L. M., Some geographical results of the Byrd Antarctic Expedition: *Geog. Rev.,* **21,** No. 2, 177–200 (1931). Structure of the Queen Maud Mountains, Antarctica: *Bull. Geol. Soc. Amer.,* **46,** 973–984 (1935).

[26] Stewart, Duncan, Jr., A contribution to Antarctic petrography: *Journ. Geol.,* **42,** No. 5, 550 (1934).

[27] Stewart, Duncan, Jr., The petrography of some rocks from South Victoria Land: *Proc. Am. Philosophical Soc.,* **74,** No. 4, 307–310 (1934). The petrography of some Antarctic rocks: *Am. Mineral.,* **19,** 150–160 (1934).

ILMENITE-HEMATITE-MAGNETITE RELATIONS IN SOME EMERY ORES

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ABSTRACT

The principal mode of occurrence of hematite and ilmenite in emery ores from a number of localities is in the form of unique exsolution intergrowths, suggesting unusual crystallization-temperature-solution conditions. Magnetite, not a component of these exsolution intergrowths, is the most abundant opaque constituent in some polished sections, but is rare, or totally absent, in others. Ilmenite exsolves from hematite to sharp magnetite-hematite boundaries, showing that much of the hematite now present crystallized originally as hematite, and is thus not a later replacement product of magnetite. Some replacement of magnetite by hematite is noted, but only a minor percentage of the total hematite present has formed in this manner.

Ilmenite of one age often exsolves parallel to two crystallographic directions within hematite. In addition, two readily distinguishable ages of exsolution ilmenite in hematite are often observed. The ilmenite bodies of each age have a characteristic orientation in the hematite. The original solid solution varied in composition from dominant hematite to dominant ilmenite.

Exsolution of hematite from corundum is well shown in some sections. In those ores in which the corundum exhibits parting, hematite exsolved both as blebs and as needles, and in the ores in which the corundum does not exhibit parting, hematite exsolved only as minute blebs.

INTRODUCTION

In the literature concerning emery deposits, much discussion is devoted to genesis and to the relations between the nonopaque minerals. The relations between the opaque minerals have been only casually mentioned, and it was with this fact in mind that the writer undertook the present study. Ores from the following places were used for study: Naxos, Greece; Whittles, Virginia; Chester, Massachusetts; Macon County, North Carolina; and Peekskill, New York. Interesting exsolution relations between ilmenite and hematite were found to be universal, and will be stressed in the descriptions to be given. Some of the features observed are believed to be peculiar to emery ores.

The only previous reference to exsolution structures in ores of this type, so far as the writer is aware, has been by Butler,[1] who merely noted their presence in the ores from Peekskill, New York. The author is deeply indebted to Professor W. H. Newhouse, who suggested this work, and who freely gave helpful advice and criticism. Thanks are due Dr. Arthur C. Bevan, State Geologist, Virginia Geological Survey,

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[1] Butler, J. W., *Am. Mineral.*, **21**, 537–575 (1936).

who kindly furnished several specimens from Whittles, Virginia. William Parrish, of the Massachusetts Institute of Technology, rendered constructive criticisms and suggestions, and John A. Shimer aided in reading the manuscript.

DESCRIPTIONS AND DISCUSSION

ORES FROM NAXOS, GREECE

General

The major portion of the ore is an aggregate of subhedral to anhedral grains of corundum, some of which are as large as 2 mm. in diameter. The corundum does not show parting. Minor small patches of hematite are present interstitially to and molded around corundum grains. The greatest dimension of any of the hematite masses measured was 1.2 mm. The hematite universally contains very minute exsolution lamellae of ilmenite. No ilmenite is present as grains, and magnetite is totally absent in the material examined.

Hematite-ilmenite exsolution relations

Because of the small size of a majority of the hematite grains, and due to the minute scale of the ilmenite exsolution, high magnification was necessary to bring out the hematite-ilmenite relations. Every patch of hematite contains minute exsolution lamellae of ilmenite, which commonly lie in one, two or three directions within hematite. The thickness of ilmenite lamellae lying in different directions frequently varies. At times the exsolution lamellae widen laterally. Exsolution of ilmenite to borders of hematite crystals is common.

The patterns formed by exsolution lamellae appear rectangular, rhombohedral, or a combination of both. Comparatively thick, tapering bodies of ilmenite commonly lie at approximately right angles to thin, hair-like lamellae. This pattern is often modified by the presence of a third set of thin lamellae, inclined at approximately 45° to both sets first described. All the ilmenite appears to be of the same age. The exsolution blades of ilmenite presumably lie parallel to (0001)[2] and to rhombohedral directions within hematite. These unusual exsolution intergrowths indicate one of several possibilities: first, the hematite now present is a product of a wholesale replacement of magnetite, preserving exsolution structures of ilmenite in the replaced mineral; or second, the present hematite existed in an original solid solution as hematite, and exsolution of ilmenite took place in an unusual manner.

[2] Ramdohr, P., *Festschr. Bergakad. Clausthal*, 307–340 (1925). Ramdohr, P., *N. Jahrb. Min., Bd.* **54,** 320–379 (1926).

Although ilmenite has been previously described as exsolving parallel to only one direction (0001) in hematite, the second possibility mentioned above seems much the more reasonable when all evidence is considered. First, no magnetite was found in the material examined. If replacement of magnetite by hematite was actually responsible for the ilmenite patterns seen, the replacement was unusually complete. Second, the presence of exsolution ilmenite at hematite crystal boundaries indicates that the present borders of the hematite crystals were the original borders. Third, the patterns found are never in the form of complete equilateral triangles, as would be expected if the ilmenite was preserved by a replacement of magnetite. Instead, exsolution ilmenite lamellae frequently lie in but one direction, or they form rectangular or rhombohedral patterns. Where combinations of the two latter patterns are present, the result in no way simulates a set of equilateral triangles. The great predominance of hematite over ilmenite in the intergrowths indicates that the original solid solution was very much richer in hematite than in ilmenite.

Exsolution of hematite from corundum

Hematite not only occurs as patches and grains, as previously described, but also as minute blebs within corundum grains. Close examination reveals that these blebs are concentrated in especial abundance, as swarms, toward the centers of certain subhexagonal corundum grains. The maximum diameter of any hematite bleb is 0.03 mm., and the average diameter is in the neighborhood of 0.005 mm. Some of the blebs exhibit a roughly hexagonal form. Their occurrence and distribution suggests their origin as an exsolution product from corundum.

Ores from Whittles, Virginia

General

The ore is fine grained, and is indistinctly banded. Pink bands in which ilmenite is the dominant constituent alternate with bands in which corundum and magnetite predominate. Corundum occurs as irregular grains and masses, but frequently shows angular boundaries. The maximum measured diameter of any corundum grain was 0.4 mm. The non-opaque constituents are slightly more abundant than the opaque minerals. No tendency for the corundum to exhibit parting was observed.

Magnetite and ilmenite occur as irregular grains, molded around and between corundum grains. The maximum measured dimension of magnetite was 0.6 mm., and for ilmenite 0.2 mm. Magnetite is somewhat more abundant than ilmenite. Hematite is present only in minor quantity, existing as fine, parallel exsolution lamellae in ilmenite, and as a replacement product of magnetite.

Hematite-ilmenite-magnetite relations

The exsolution hematite occurs as very minute lamellae lying in one direction within ilmenite. This type of exsolution is a good example of the common exsolution parallel to the basal pinacoid.[3,4,5] The replacing hematite occurs in the form of equilateral triangular patterns in the vicinity of fractures and boundaries of magnetite grains. Contacts between magnetite and ilmenite are sharp and distinct. The relative quantity of the two solid phases in the intergrowths shows that the ilmenite-hematite solid solution was in this case exceedingly rich in ilmenite (Ti) and poor in hematite (Fe).

Exsolution of hematite from corundum

Exsolution hematite within corundum occurs as very minute blebs, often beautifully aligned. In some corundum grains, lines of hematite blebs lie in two directions, and in other corundum grains, in three directions. Lack of definite data here renders impossible the accurate determination of the orientation of the exsolution hematite.

Emery Ores from Chester, Massachusetts

General

Polished surfaces reveal a fine banding of the opaque and nonopaque minerals. Corundum is not abundant, occurring as irregular grains with an average diameter of about 0.5 mm. Several corundum grains exhibit excellent rhombohedral parting and twinning. Much of the corundum has been considerably altered. Magnetite occurs as numerous subcircular to subelliptical, worm-like masses which appear to corrode the corundum.

Magnetite is also present as numerous angular grains, up to 1.3 mm. in diameter. Hematite is usually interstitial to magnetite grains, and is about one tenth as abundant as the latter. The larger hematite grains measure about 0.10 mm. in diameter, and always form parts of intricate exsolution intergrowths with ilmenite. Magnetite is not a component of these intergrowths.

Hematite-ilmenite-magnetite relations

There are two distinct types of exsolution ilmenite present within hematite. First, a salmon-colored ilmenite, which occurs as irregular

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[3] Ramdohr, P., *loc. cit.*

[4] Schneiderhöhn-Ramdohr, Lehrbuch der Erzmikroskopie, Bd. **2**, 539–550 (1931).

[5] Schwartz, G. M., *Econ. Geology*, **26**, 739–763 (1931).

plate-like masses and thick lamellae. Second, a later, cream-colored ilmenite, which occurs as thin blades and as irregular masses at the boundaries of hematite grains and crystals. That the cream-colored ilmenite exsolved later than the salmon-colored ilmenite is proven in many cases where blades of the later ilmenite crosscut plates or thick lamellae of the earlier, darker ilmenite, or project into "embayments" in the latter. The later ilmenite also piles up against plates or lamellae of the earlier ilmenite.

The early ilmenite usually contains a further exsolution of hematite as minute blades parallel to the lengths of ilmenite plates or lamellae. This strongly suggests that the early ilmenite exsolved parallel to the (0001) direction in hematite. That this is the case is shown by the fact that the hematite shows maximum extinction, in polarized light, parallel to the lengths of the earlier ilmenite bodies (the position of maximum extinction for hematite is parallel to the (0001) direction). In polarized light, the bodies of both types of ilmenite show extinction parallel to their longer dimensions. The later, light-colored ilmenite often exsolved in two directions within hematite, and a rhombohedral pattern similar to that shown in Fig. 1 was the result. The orientation of the later ilmenite appears to be, then, parallel to the rhombohedral directions in hematite. (Since the earlier ilmenite lies parallel to (0001) in hematite, and since the longer dimensions of the later ilmenite are different from those of the earlier ilmenite, the blades of later ilmenite are certainly not oriented parallel to (0001) of hematite.) The thickness of blades parallel to one rhombohedral direction is commonly greater than that of the blades in the other rhombohedral direction. This may be due to the orientation of the polished sections.

In cases where the later ilmenite exsolved parallel to two directions in the same hematite grain in which earlier ilmenite was present, a pattern like that shown in Fig. 2 was the result. One set of blades of the later ilmenite are seen lying at about right angles to the direction assumed by the earlier, darker ilmenite.

Ilmenite forms a large proportion of the material present in the intergrowths, which shows that the original solid solution was quite rich in ilmenite. The earlier, dark ilmenite appears to be normal ilmenite, but the lighter, later ilmenite is apparently a variety rich in Fe_2O_3. The cream-colored ilmenite is much more resistant to hydrofluoric acid than is the darker variety, and sometimes shows a slight internal reflection. Otherwise, the properties of the two are identical. No replacement of magnetite by hematite was noted in the material examined, and this fact, together with the observation that exsolution ilmenite from hematite was usually present at hematite-magnetite boundaries and at hematite crystal boundaries, seems to indicate that the hematite now present was originally present in a solid solution as hematite, and therefore did not form as a replacement product of magnetite.

ORES FROM MACON COUNTY, NORTH CAROLINA

General

The opaque and nonopaque minerals are here present in approximately equal proportions. The ore consists of alternating crude bands of corundum and opaque minerals. The corundum occurs as subhedral to anhedral grains up to 2.5 mm. in diameter, and often exhibits very well developed rhombohedral parting and twinning. Scattered small grains of hematite occur within corundum. In the bands composed mainly of opaque minerals, hematite occurs in irregular grains up to 2 mm. in diameter. Magnetite, about one half as abundant as hematite, is also present in these bands as very irregular grains, the largest of which are about 0.5 mm. in diameter. The magnetite tends to occur toward the margins of the bands. Ilmenite is present in great abundance as exsolution intergrowths within hematite. The hematite sometimes possesses twinning.

Hematite-ilmenite-magnetite relations

Here again the exsolution ilmenite is of two ages. The early, darker ilmenite occurs as small, irregular, subrectangular to subtriangular masses, which are aligned parallel to one direction in hematite. The later, lighter-colored ilmenite is similar to that described in the Chester, Massachusetts, ores. Figures 1 and 2 again may be used to illustrate typical relations between hematite, ilmenite, and magnetite. Here again evidence indicates that the early ilmenite exsolved parallel to the (0001) direction of hematite, and that the later ilmenite exsolved parallel to rhombohedral directions.

A strip of lighter ilmenite is commonly found at hematite-magnetite contacts, and at hematite crystal boundaries. This fact suggests that the present boundaries between magnetite and hematite were the original boundaries between these two minerals. The original hematite-ilmenite solid solution contained about twice as much hematite as it did ilmenite. Some replacement of magnetite by hematite along octahedral directions was noted, but only adjacent to fractures in the magnetite, or at corundum-magnetite contacts. This type of hematite is very minor in quantity

Exsolution of hematite from corundum

Numerous minute needles of hematite can be seen crosscutting the parting and twinning directions of corundum at angles of about 45°. These needles lie parallel to the lengths of corundum grains. It appears as though these hematite needles originated as an exsolution product from corundum, and lie parallel to the *c*-axis of the latter. The needles of hematite appear identical to those shown in Fig. 4.

ORES FROM PEEKSKILL, NEW YORK

General

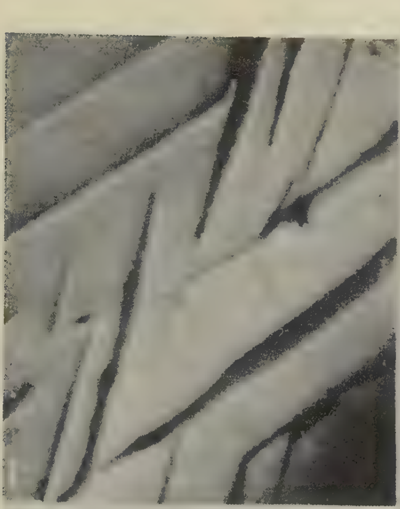
Nonopaque minerals greatly predominate over opaque minerals in the Peekskill ores. Irregular patches of metallic minerals occur interstitially to grains of several nonopaque minerals. The patches of metallic minerals often interconnect to form networks. Corundum usually shows rounded, irregular boundaries against the opaque constituents. The corundum exhibits parting.

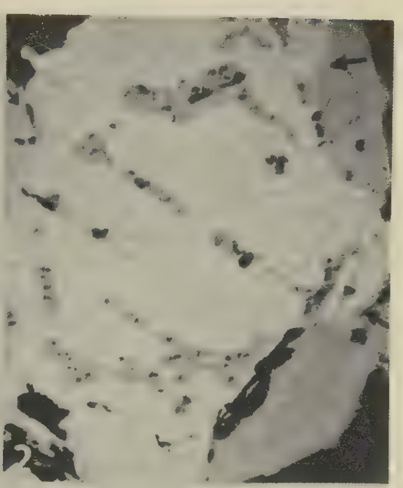
Of the opaque minerals present, hematite and ilmenite are by far the most abundant. These minerals occur, as a whole, in approximately equal proportions, always intergrown one with the other. Hematite grains reach a diameter of 1 mm. Magnetite, minor in quantity, occurs as small, irregular grains up to 0.3 mm. in diameter.

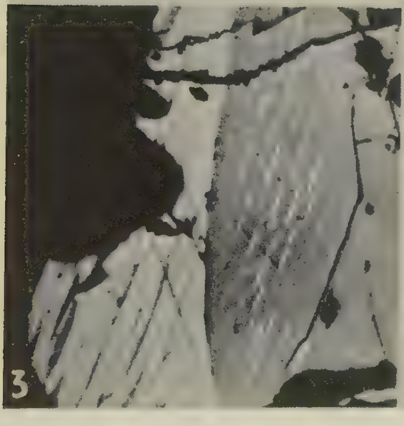
Hematite-ilmenite-magnetite relations

Hematite and ilmenite universally exhibit exsolution intergrowths one with the other. The textures produced are rather coarse, because of the large proportion of ilmenite to hematite in the original solid solution. Coarse blades of ilmenite are found parallel to the (0001) direction in hematite. The exsolution blades of ilmenite always show a further exsolution of hematite blades parallel to their lengths, and hence parallel to their (0001) directions. In grains in which ilmenite predominated in the original solid solution, the relations just described are reversed. In cases where the solid solution contained equal proportions of hematite and ilmenite, a structure such as that shown in Fig. 3 was the result of mutual exsolution.

Ilmenite frequently exsolved from hematite to hematite-magnetite contacts. Where hematite was in contact with both magnetite and corundum, ilmenite usually exsolved to hematite-magnetite boundaries in preference to hematite-corundum contacts. Contacts between ilmenite masses and grains of magnetite are always sharp and definite, and no replacement of magnetite by either hematite or ilmenite was seen. Here again the hematite now present appears to have been present originally







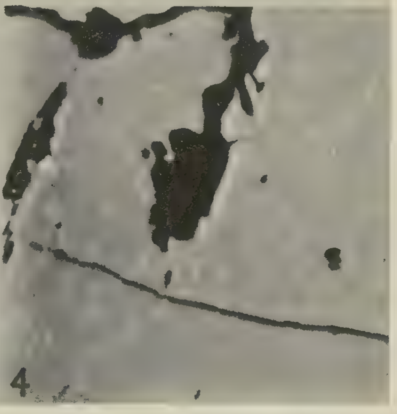


FIG. 1. Photomicrograph of blades of exsolution ilmenite (dark) in hematite (light) ×950. Note rhombohedral pattern formed by the exsolution blades. Locality: Macon County, North Carolina.

FIG. 2. Photomicrograph of exsolution ilmenite (dark) of two ages within hematite (light). ×230. Magnetite surrounds the hematite grain. Darker ilmenite is the older. Note exsolution of later ilmenite to form rhombohedral patterns, and "piling up" of later ilmenite at magnetite-hematite boundaries (see arrows). Locality: Chester, Mass.

FIG. 3. Photomicrograph of common exsolution structure in Peekskill ores. ×235. Hematite light, ilmenite dark (with exsolution blades of hematite), magnetite dark (lacking exsolution structure). Note parallelism of all exsolution blades. Locality: Peekskill, New York.

FIG. 4. Photomicrograph of exsolution needles of hematite in corundum. ×300. Locality: Peekskill, New York.

in a solid solution as such, and thus is not a later replacement product of magnetite. The original solid solution contained approximately equal proportions of ilmenite and hematite.

Exsolution of hematite from corundum

Numerous examples of hematite exsolution from corundum are present, both as tiny blebs and as needles (Fig. 4). The blebs and needles have characteristics identical with those previously described in other ores.

SUMMARY AND CONCLUSIONS

From the preceding discussion and descriptions, the following points may be emphasized:

1—In the emery ores examined, hematite is chiefly a primary mineral, and not secondary after magnetite. This is shown by the continual presence of exsolution ilmenite at the borders of the crystals. Hematite resulting from the replacement of magnetite is comparatively negligible in quantity.

2—In some of the ores examined, exsolution ilmenite in hematite is of two types: first, an earlier, dark-colored type, which exsolved parallel to (0001), and second, a light-colored variety of ilmenite, which apparently exsolved parallel to rhombohedral directions. The age relations are quite clear. This "two-stage" exsolution of ilmenite is quite different from the type described by Ramdohr, who advanced the "two-stage" explanation for exsolution bodies of ilmenite and hematite which existed only in the common (0001) direction.

3—Because of the exsolution relations seen in these ores, rather unusual temperature-crystallization-solution conditions must have prevailed during the formation of the ores.

4—The original solid solution varied in the various ores from dominant hematite to dominant ilmenite.

5—So far as the writer is aware, the following features are peculiar to emery ores: (a) The exsolution of ilmenite from hematite in several directions, forming rhombohedral patterns, and (b) the age-orientation relationships between exsolution ilmenite and hematite previously described under (2).

6—In ores where exsolution hematite exists only as blebs in corundum, the corundum does not show parting. Where exsolution hematite is present mainly as needles, the corundum exhibits parting.

NOTES AND NEWS

INSTITUTO DE GEOLOGIA, CARACAS, VENEZUELA

N. B. Knox, *Director of the Institute.*

The Instituto de Geología was formally opened on September 15, 1938, in the presence of President López, Contreras of Venezuela. Classes began that day with a registration of twenty-four selected students.

The Institute is fully equipped for the training of students in the fields of general geology, petroleum geology, and mining geology. It is housed in its own building which contains a large lecture hall, several recitation rooms, separate laboratories for chemistry, mineralogy, petrography, paleontology and economic geology, a drafting room, a research laboratory for the staff, a preparation room for the cutting, grinding, and polishing of specimens and thin sections, and a workshop. Also included in the Institute are a paleontologic museum and a large library. All the laboratories are equipped with the latest apparatus for the investigation of geologic problems.

In addition to courses in mineralogy, economic geology, petroleum geology, paleontology, stratigraphy, sedimentation, field geology, etc., basic courses in chemistry, physics, botany and zoology, mathematics, drafting, hygiene, mining and petroleum laws and language are given. The Institute also has its own physician who, in addition to his medical duties, will teach hygiene.

The Institute as at present constituted will give a bachelor's degree in geology at the end of four years of study, half of the fourth year being spent in the field. It is planned, later on, to extend the scope of the Institute so as to be able to grant higher degrees.

While the Instituto de Geología is a part of the Ministry of National Education, it has been organized by a committee of professional geologists from the Ministry of Industries Geological and Mining Service.

These men, trained in Europe or the United States, now form the Institute's Board of Regents. They are Drs. V. M. López (Chairman of the Board), M. Tello, P. I. Aguerrevere, Santiago E. Aguerrevere and G. Zuloaga. The faculty includes N. B. Knox, Technical Director and Professor of Geology; Ely Mencher, Professor of Paleontology; Bela Muracosy, Professor of Topography; and Hermann Kaiser, Professor of Chemistry.

There are no tuition fees for Venezuelans at the Institute but candidates must pass examinations in mathematics, chemistry, physics, biology, English and French before being admitted. The course is four years and leads to a degree. Six scholarships have been granted to students from other North and South American countries.

Many of the students are on scholarships provided by the oil companies operating in Venezuela, which give the student not only cash to live on, but opportunity for field and laboratory work during vacations.

BOOK REVIEW

CONTRIBUTIONS TO THE KNOWLEDGE OF THE CHEMICAL COMPOSITION OF THE EARTH'S CRUST IN THE EAST INDIAN ARCHIPELAGO, I, II.

I. The spectrographic Determination of the Elements according to Arc Methods in the Range 3600–5000 Å.

II. On the Occurrence of Rarer Elements in the Netherlands East Indies.

W. Van Tongeren, Assistant in Mineralogy, University of Utrecht. Pp. 181, Figs. 14, 19½×26½ cm. D. B. Centen's Uitgevers—Maatschappij N. V. *Amsterdam*, **1938**. Price dutch fl. 4.50: Part I alone, dutch fl. 3.

This book describes a composition analysis by spectrographic methods of about 300 samples of rocks and minerals from the Dutch East Indies. The study concerns only the estimation of the rarer elements, which, determined as oxides, were present in amounts of 1% or less. For such analyses the spectrograph has a great advantage, since, by examination of a single spectrogram—in an hour or so—a large number of elements may be determined, with a precision at least as good as that of chemical methods in the low percentages, and often better in the minute percentages. Any spectrographic analysis is a comparative method and involves, first, a choice of a suitable light source and, second, a calibration of the apparatus by the use of natural or artificial samples of known composition. Dr. Van Tongeren has used in his work the light from the "cathode layer" of a carbon arc, according to the technique developed by Mannkoff and Peters in Professor Goldschmidt's Mineralogical Laboratory at Göttingen University. In this method, which is especially suitable for mineral and other non-conducting samples, the pulverized sample is placed in a cavity of the lower, negative electrode of a carbon arc and the light studied is that emitted in the "cathode layer," just above the cathode. Comparison, in number and intensity, of the spectral lines of the various elements with those emitted by known percentages of the same elements in the standard samples permits an estimate of the percentage of each element.

Part I describes the apparatus, and the preparation and use of the standard samples, which were made by grinding up known amounts of the oxides of the various elements with quartz powder. The method could be applied to all of the metals and metalloids, with, of course, varying sensitivities. Actually, for various reasons, fifty elements were tried and about thirty-five, including most of the rare earths, were found to give satisfactory results for the problem in hand.

Part II gives the detailed result of the spectrographic examination of 300 mineral samples. Twenty-eight of the elements sought were found in determinable quantities, ranging from .0001% up to 1% or more. Average values are given for the amount of these rare elements in the earth's crust in the Dutch Indies and there is some discussion of their presence on the basis of atomic theory. The accuracy appears to be a factor of about two in either direction. It could, of course, be greatly improved by the substitution of a photometer for eye estimation of spectral-line intensities. However, the work amply demonstrates the power of the spectrograph for rapid analytical survey of mineral composition. It is a valuable pioneer work in a new field and the author promises more extensive and accurate data.

The printing and paper are excellent. As is to be expected in a book written and printed in English in a foreign country, some errors in vocabulary, usage, and typography appear. However, these faults interfere but little with reading the work, and the style, in general, is clear and straight forward. By writing in English Dr. Van Tongeren has wisely made his work available to a much wider circle of readers.

R. A. Sawyer, *University of Michigan*

PROCEEDINGS OF THE NINETEENTH ANNUAL MEETING OF THE MINERALOGICAL SOCIETY OF AMERICA AT NEW YORK, N. Y.

Paul F. Kerr, *Secretary*

The nineteenth annual meeting of the Society was called to order Wednesday, December 28th, at 2 P.M. in the Jade Room of the Waldorf-Astoria Hotel, New York, N.Y., President Ellis Thomson presiding. The customary business of the Society was conducted, including reports of the officers of the Society and committees summarized as follows:

Minutes of the Eighteenth Annual Meeting held in 1937.

Report of the Secretary.

Report of the Editor.

Report of the Treasurer.

Report of the Auditing Committee.

After announcements regarding the Semi-Centennial celebration of the Geological Society of America, the meeting was adjourned and the president called for the presentation of papers. The report of the election of officers and fellows for 1939, and the reports of the Secretary, Editor, Treasurer and Auditing Committee are given in the following pages.

ELECTION OF OFFICERS AND FELLOWS FOR 1939

The secretary announced that 299 ballots had been cast for the officers of the society as nominated by the Council. The officers for 1939 are as follows:

President: Max N. Short, University of Arizona, Tucson, Arizona.
Vice-President: Burnham S. Colburn, Greystone Court, Biltmore, N.C.
Secretary: Paul F. Kerr, Columbia University, New York, N.Y.
Treasurer: Waldemar T. Schaller, U. S. Geological Survey, Washington, D.C.
Editor: Walter F. Hunt, University of Michigan, Ann Arbor, Mich.
Councilor, 1939–42*:* Carl Tolman, Washington University, St. Louis, Mo.

The secretary announced that according to the provisions of the constitution, the following had been elected to Fellowship in the Mineralogical Society of America:

George W. Bain, Amherst College, Amherst, Massachusetts.
Milton N. Bramlette, U. S. Geological Survey, Washington, D.C.
Newton W. Buerger, Dept. of Mineralogy, Queen's University, Kingston, Ontario, Canada.
Eugene Callaghan, U. S. Geological Survey, Washington, D.C.
Harold W. Fairbairn, Massachusetts Institute of Technology, Cambridge, Massachusetts.
Cornelius S. Hurlbut, Jr., Harvard University, Cambridge, Massachusetts.
William Q. Kennedy, 19 Grange Terrace, Edinburgh, Scotland.
Thomas S. Lovering, University of Michigan, Ann Arbor, Michigan.
John P. Marble, U. S. National Museum, Washington, D.C.
Thomas N. McVay, University of Alabama, University, Alabama.
William M. Myers, Pennsylvania State College, State College, Penn.
Joseph H. Pratt, Chapel Hill, North Carolina.
S. James Shand, Columbia University, New York, N.Y.
Jasper L. Stuckey, North Carolina State College, Raleigh, N.C.

REPORT OF THE SECRETARY FOR 1938

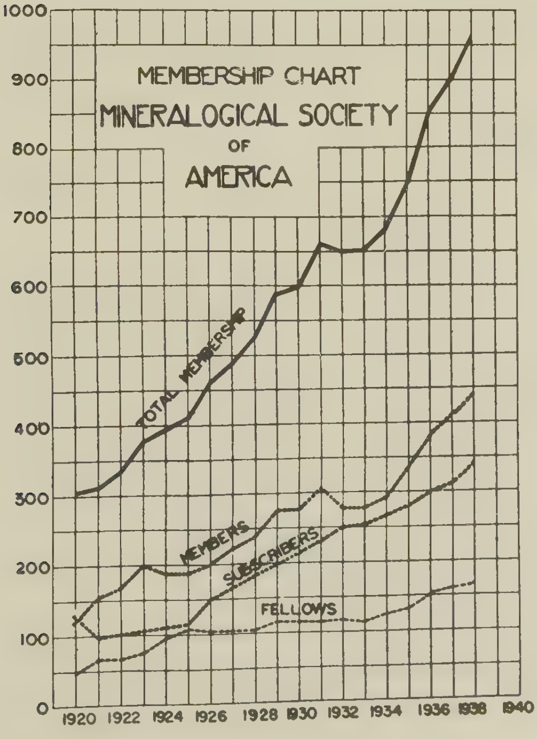
To the Council, Fellows and Members:

MEMBERSHIP STATISTICS

	1937	1938
Correspondents	5	8
Fellows	160	171
Members	414	441
Subscribers	317	339
	896	959

GAIN AND LOSS FOR 1938

	Gain	Loss
Correspondents	3	0
Fellows	14	3
Members	88	61
Subscribers	40	18
	145	82



During 1938, the Mineralogical Society of America has made a net gain in membership of 63, or 7% on the basis of the 1937 total. This increase is greater than was made in 1937. There has been a gain in both members and subscribers and, as in previous years, the greater gain has been in members. It is interesting to note, however, that the increase in subscribers for 1938 is almost double that for 1937, while the gain in members for 1938 is the same as that for 1937. In the past year, subscribers from two additional states and two more foreign countries have been added to the enrollment. At the present time, the society has subscribers in 41 states and 28 foreign countries. The membership chart has been brought up to date and accompanies this report.

Respectfully submitted,
Paul F. Kerr, *Secretary*

ANNOUNCEMENT REGARDING THE REPORT OF THE NOMENCLATURE COMMITTEE

The Secretary's office wishes to report that the ballot on the report of the Committee on Nomenclature is complete. Ballots were mailed to all Fellows of the Society, who were asked to pass upon the report of the Nomenclature Committee as published in the March 1936 issue of *The American Mineralogist*, and amended by the Council of the Mineralogical Society of America.

The amendment which replaces paragraph 3, page 189, March 1936, is as follows:

"If the report here presented is approved and adopted by the Society, it is recommended that the changes enumerated below be followed in future mineralogical descriptions, whenever possible, and that the Editor of *The American Mineralogist* and Editors of similar journals (*Am. Jour. Sci.*, *Econ. Geology*, etc.) be advised of this action by the Society."

The Secretary's office wishes to report that a majority of the fellows responded and with one exception the ballots received were in the affirmative.

Respectfully submitted,
Paul F. Kerr, *Secretary*

REPORT OF THE EDITOR FOR 1938

To the Council, Fellows and Members of the Mineralogical Society of America:

In presenting a brief report on the accomplishments for the year 1938, attention is naturally directed to the scope and character of the various items that have appeared in the current volume. With the conclusion of the December issue, the total pagination has exceeded slightly the 900 page mark. It should be noted that the past two years have been characterized by unusual publication activity, due largely to the issuance of special numbers. This past year the special November issue, sponsored by Professor Palache and his co-workers at Harvard, contained 11 articles and contributed 182 pages towards the 906 page volume. As in previous issues of this character, publication by the Society was made possible through financial assistance received from the Department of Mineralogy of Harvard University. Also, a generous contribution from the Geological Society of America of $1500 a year, for the past five years, has been an important factor in stimulating an expanded publication program.

In summarizing the activities for the year, we find that volume 23 contained 69 leading articles. Of this number, 47 were in the four fields of descriptive mineralogy, structural crystallography, geometrical crystallography and petrography. The average length of these longer papers is 11 printed pages. If to these major contributions we add the 22 shorter papers that were accepted, we attain a total of 91 published manuscripts for the calendar year. These contributions were received from 96 contributors associated with 44 different universities, research bureaus and technical laboratories.

An unusually large number of new mineral species was described during 1938. The eleven new minerals include: leightonite, antofagastite, bandylite, ungemachite, clino-ungemachite, veatchite, yeatmanite, johannsenite, metasideronatrite, parabutlerite, and parahilgardite.

The somewhat cosmopolitan character of the Society's journal has been maintained this past year by virtue of 12 papers received from beyond our own borders.

Realizing that a report covering any single year would be inadequate to appraise the general service rendered by *The American Mineralogist*, friends of the Society might be interested in a few facts covering the operations of the journal for the past five years. During this period, 1934–1938, *The American Mineralogist* has printed 4408 pages, not including the 98 page decennial index; 347 leading articles have been published, 35 of which originated outside of the United States. The 12 countries that supplied these 35 papers were: Canada 12, England 7, Soviet Russia 3, Belgium 3, Holland 2, Norway 2, and 1 each from China, Japan, Switzerland, Bolivia, Sweden and Australia.

The accompanying table of contents summarizes in detail the distribution of subject matter in volume 23.

Distribution of Subject Matter in Volume 23

Subjects	*Articles*	*Pages*	*Per Cent of Total*
Leading articles*			
Descriptive mineralogy	17		
Chemical mineralogy	5		
Structural crystallography	9		
Geometrical crystallography	11		
Petrography	10		
Optical mineralogy	5		
Memorials, miscellaneous	12		
	69	764	84.3
Short articles	22	57½	15.7
Proceedings of societies	27	74	
Notes and news	9	3	
Abstracts of new mineral names	21	6½	
Book reviews	4	1	
Total of text	152	906	100.0
Illustrations	274		
Index, covers, advertisements		126	
Total		1032	

* (Average length of leading articles, 11 printed pages.)

Respectfully submitted,

Walter F. Hunt, *Editor*

REPORT OF THE TREASURER FOR 1938

To the Council of the Mineralogical Society of America:

Your Treasurer submits herewith his annual report for the year beginning December 1, 1937, and ending November 30, 1938.

RECEIPTS

Cash on hand December 1, 1937	$2,873.40	
Dues and subscriptions	2,718.92	
Advertisements	380.42	
Sale of back numbers	403.57	
Authors' charges on separates	761.86	
Interest on endowment (bonds)	2,356.15	
Interest on endowment (stocks)	68.75	
Sale of 20-volume index	35.01	
Geological Society of America grant for 1938	1,500.00	
Principal of U. S. Postal Savings bonds, transferred from Roebling Medal Fund, 1937	300.00	
Cash, transferred from Roebling Medal Fund, 1937	75.00	
Cash, transferred from endowment funds, 1937	248.60	
Partial payments (1938) on principal of Trenton Mortgage Service Company's preferred stock	160.68	
Principal of called (at 105) Denver Gas & Electric Light Company's 5% bond, less bank collecting charge of $1.39	1,048.61	
		$12,930.97

DISBURSEMENTS

Printing and distribution of the Journal (12 issues)	$ 5,358.58	
Printing and distribution of separates	822.83	
To the Editor, Secretary, and Treasurer	970.00	
Postage	127.74	
Printing	86.21	
Stationary	14.75	
Clerical help	322.00	
Committee expenses	18.95	
Safety deposit box	8.25	
Bank collecting charges	2.92	
Telegrams	4.07	
Refund on dues	6.00	
Advertising commission	5.63	
Check returned	3.00	
Denver Gas & Electric Light bond coupon returned	25.00	
Balance of payment, Roebling Medal, 1937	395.39	
Roebling Medal, 1938	105.00	
Securities bought for endowment fund	2,349.11	
	$10,625.43	
Cash balance November 30, 1938	2,305.54	
		$12,930.97

The endowment funds of the Society as of November 30, 1938, consist of the following securities and cash:

4 $100 bonds, Great Northern Railway Co., Genl. mtg., 5½%, due January 1, 1952	$ 400.00
2 $500 bonds, Union Pacific Railroad Co., First lien and ref. mtg., 4%, due June 1, 2008	1,000.00
45 $1,000 bonds, City and County of Honolulu, Territory of Hawaii, Water Works, 5%, due April 15, 1954	45,000.00
37–514/1000 shares, Preferred Stock, Trenton Mortgage Service Co., Trenton, N.J.	3,590.72
5 shares, American Telephone & Telegraph Co., common stock	620.57
5 shares, Public Service of New Jersey, 8% preferred stock	702.00
5 shares, United States Steel, 7% preferred stock	502.45
Cash[a] from The Denver Gas and Electric Light Co., First and ref. mtg., 5% bond, called at 105, November 1, 1938	1,048.61
	$52,864.35

[a] Carried temporarily in the current account of the Society.

Respectfully submitted,
WALDEMAR T. SCHALLER, *Treasurer*

DANA FUND

Statement of the Special Dana Fund of the Mineralogical Society of America, initiated by Prof. E. S. Dana, and since his death cared for by the Treasurer. Disbursement made to the daughter of Prof. F. Berwerth, in Vienna.

RECEIPTS

Available balance, November 30, 1937	$1,118.17	
Interest	20.75	
Contribution	10.00	
		$1,148.92

DISBURSEMENTS

Disbursed	$ 180.00	
Available balance, November 30, 1938	968.92	
		$1,148.92

Respectfully submitted,
WALDEMAR T. SCHALLER, *Treasurer*

REPORT OF THE AUDITING COMMITTEE

To the President of the Mineralogical Society of America:

The Auditing Committee has examined and verified the accounts and report of the Treasurer of the Mineralogical Society of America, for the fiscal year ending November 30, 1938. The securities listed in the Treasurer's report, with all future coupons on the coupon bonds attached, were found to be in the safety deposit box at the American Security and Trust Company of Washington, D.C.

Respectfully submitted,
Clarence S. Ross
Edward P. Henderson
John W. Greig

MINERALOGICAL SOCIETY OF AMERICA ANNUAL LUNCHEON

On Wednesday, December 28th, members and friends of the Mineralogical Society of America assembled in the Basildon Room of the Waldorf-Astoria Hotel for the annual luncheon of the Society. After a most enjoyable luncheon, President Ellis Thomson announced the second presentation of the Roebling Medal.* Dr. Esper S. Larsen of Harvard University made the presentation address and presented the Roebling Medal to Dr. Waldemar T. Schaller of the U. S. Geological Survey. Dr. Schaller, in accepting the medal from the Society, spoke of his acquaintance with Colonel Washington A. Roebling and quoted excerpts from Colonel Roebling's letters.

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* Presentation address and acceptance, *Am. Mineral.*, **24**, 53–58 (1939).

PRESENTATION OF PAPERS

A HISTORY OF THE STUDY OF ORE MINERALS

(*Presidential Address*)

ELLIS THOMSON

A history of progress made in the study of ore minerals from the start of the last century up to the present day. The developments along the main avenues of approach were passed in review. These include studies of general methods, abrasives and polishing methods, chemical methods, mill-products, quantitative macroscopic and microscopic analysis, technique, and *x*-ray methods. (Complete address is printed in this issue.)

SILICIFIED WOOD IN DOLOMITE*

JULIAN D. BARKSDALE†

Small logs and broken pieces of jet black silicified wood occur in dolomite beds of Karnic age outcropping in the Sonoma Range, Nevada. In thin sections some of the specimens of wood, tentatively identified as *Araucarioxylon*, show perfect preservation of their cellular structure by the infiltration of siliceous solutions now crystallized as quartz. Single anhedrons of quartz sometimes include several cells filling even the smallest openings in the cell walls. The crystallization of the quartz in other specimens has disrupted the cell walls and produced a coarse pseudo-cellular structure controlled by the crystallographic directions in the growing quartz grains as they attempted to clear themselves of the carbonaceous material. The difference in type of preservation is thought to be due to the difference in condition of the woods at time of silicification. The black color of the wood is due entirely to its carbonaceous content. Chips fired in a ceramic furnace have the appearance of unglazed white tile.

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* Presented through the Geological Society of America.

† Introduced by G. E. Goodspeed.

EUROPEAN COLLOFORM ORES OF MISSISSIPPI VALLEY TYPE*

CHARLES H. BEHRE, JR.

Lead-zinc ores of "Mississippi Valley type" in certain districts of western Europe, like those of the Upper Mississippi Valley district in the United States, show distinctive mineralogic features. In calcareous country rock the ore and gangue minerals, as usual and as already noted in the literature, are typically blende (often light-colored), galena, pyrite (and marcasite), barite, fluorite, calcite, dolomite, ankerite, and quartz. Especially characteristic are the colloform masses of wurtzitic blende banded alternately with the other sulphides, galena being largely in the interior of the masses. In districts where the country rock is non-calcareous, these types are not known; the minerals of the gangue change and the colloidal appearance of the ore minerals is conspicuously absent, as especially well shown at Aachen and in the Rhine Valley.

These facts suggest that (1) the calcium ions in the gangue minerals and (2) the colloform structures of most of the ores are due to the influence of the calcareous country rock.

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* Presented through the Geological Society of America.

THE MORPHOLOGY OF MECHANICAL TWINNING IN CRYSTALS

JAMES FORBES BELL

Since the discovery of mechanical twinning in calcite by Brewster in 1816, mineralogists and crystallographers have used the morphologic relationship between the faces of a crystal before and after deformation to determine the twinning elements which can be mechanically produced in crystals. These relationships have been used in connection with the constants of a strain ellipsoid developed by a process of simple shear which was proposed as a geometrical means of describing mechanical twinning by Liebisch in 1889. Analytical expressions for the indices of a crystal face in the untwinned crystal in respect to the indices of the same face after reorientation and referred to the axes of the twinned crystal in terms of the constants of a strain ellipsoid were derived by O. Muegge in 1889. These formulae have been used as an indirect solution of the twinning elements by most crystallographers since that time. A new and direct graphic solution of the twinning elements from the relative positions in respect to the original crystal axes of two or more faces before and after deformation was presented.

The differences between the morphology of a mechanically twinned crystal and a growth twin involving the same twinning elements were explained.

A compilation of all of the work which has been done on mechanical twinning and new investigations attempting to correlate the twinning elements and the crystal structure are now being carried on.

A MICRO-BALANCE FOR SPECIFIC GRAVITY DETERMINATION

HARRY BERMAN

A micro-balance of the torsion type has been applied, after slight modification, to the measurement of specific gravities of fragments from 3 to 50 milligrams. The attainable accuracy is well within one per cent, and the time required for the necessary measurement is only a few minutes.

COMPOSITION AND OPTICS OF COPIAPITE

L. G. BERRY

From *x*-ray and density measurements on analyzed copiapite from Chuquicamata, Chile, Peacock has obtained triclinic structural elements and the cell formula:

$$X(\mathrm{OH})_2\mathrm{Fe}'''_4(\mathrm{SO}_4)_6\cdot n\mathrm{H}_2\mathrm{O}$$

in which X represents several bases amounting to one oxygen equivalent.

Reduction of many analyses of copiapite to 6 atoms of sulphur, instead of the usually accepted 5, confirms this formula and shows that the component X may be $\frac{2}{3}$R'''(Fe''', Al), 1 R''(Fe'', Mn, Cu, Zn, Ca, Mg), or 2 R'(Na, K), and the full value of n is 20. For the varieties in which X is mainly Fe''', Fe'', or Mg (each represented by several good analyses), the names *ferricopiapite* (natural and artificial), *ferrocopiapite* and *magnesiocopiapite*, respectively, are proposed. For the variety in which X is mainly copper, the name *cuprocopiapite* was recently proposed by Bandy. Ferricopiapite and cuprocopiapite are also optically distinguishable from ferrocopiapite or magnesiocopiapite, which are optically similar.

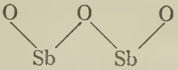
THE MECHANISM OF THE GENESIS OF POLYMORPHOUS FORMS

MORTIMER C. BLOOM

Polymorphous forms are found throughout the mineral kingdom under conditions of apparent thermodynamic instability. The mechanism of the genesis of such forms was the subject of this paper.

In the $\mathrm{Sb_2O_3}$ system, precipitation from pure aqueous solutions gives the stable senarmontite structure. Sufficiently acid solutions generate the unstable valentinite structure which contains some of the acidic constituents in solid solution, thus increasing its thermodynamic stability. Acid concentration is not the sole factor. The anion of the acid has a marked effect.

These results are determined by (a) the nature of the groups in solution, (b) the nature of the available crystal structures. The low temperature structure of $\mathrm{Sb_2O_3}$ consists of discrete $\mathrm{Sb_4O_6}$ molecules, the high temperature structure of chains composed of units of the following type:



Acid antimonious solutions contain antimony predominantly in the form of SbO^+ ions and organization into the valentinite chains is easily effected by elimination of H_2O between two SbO–OH groups. Recent crystal structure work has shown analogous groups in α-FeOOH, β-FeOOH, AlOOH, and MnOOH. That such groups are formed in acid antimonious solutions is indicated by the fact that precipitates from such solutions are very hydrous.

The valentinite structure has large channels capable of housing HCl readily, $HClO_4$ with some distortion. HCl gives rise to the valentinite structure at acid concentrations where $HClO_4$ gives rise to a mixture predominantly of the senarmontite structure.

Analogous studies will probably indicate analogous mechanisms for the genesis of polymorphs in other systems.

ILMENITE-HEMATITE-MAGNETITE RELATIONS IN SOME EMERY ORES

JOSEPH M. BRAY

The major mode of occurrence of hematite and ilmenite in emery ores from a number of localities is in the form of unique exsolution intergrowths, suggesting unusual crystallization-temperature-solution conditions. Magnetite, not a component of these exsolution intergrowths, is the most abundant opaque constituent in some polished sections, but is rare or totally absent in others. Ilmenite exsolves from hematite to sharp magnetite-hematite boundaries, showing that much of the hematite now present crystallized originally as hematite, and is thus not a later replacement product of magnetite. Some replacement of magnetite by hematite is noted, but only a minor percentage of the total hematite present has formed in this manner.

Ilmenite of a single age often exsolves parallel to two crystallographic directions within hematite. In addition, two readily distinguishable ages of exsolution ilmenite in hematite are often observed. The ilmenite bodies of each age have a characteristic orientation in the hematite. The original solid solution varied from dominant hematite to dominant ilmenite.

Undoubted exsolution of hematite from corundum is very well shown in some sections. A further study of these intergrowths is in progress.

THE CRYSTAL STRUCTURE OF GUDMUNDITE

M. J. BUERGER

The crystal structure of gudmundite, FeSbS, has been completely determined. The ordinary gudmundite "crystal," in common with other members of the arsenopyrite group, is actually a twinned composite simulating a single orthorhombic individual. The composite gives orthorhombic *x*-ray diffraction effects, but a properly separated fragment gives monoclinic diffraction effects. The space group is C_{2h}^5. New, revised, cell data are:

	referred to primitive cell $P2_1/c$	referred to side-centered cell $B2_1/d$ (axes comparable with marcasite axes)
	$a=6.02$ A.	$A=10.00$ A.
	$b=5.93$	$B=5.93$
	$c=6.02$	$C=6.73$
	$\beta=67°52'$	$\beta=90°00'$
Formula weights per cell	4 FeSbS	8 FeSbS
calculated density	6.93	

All atoms are in the general position. A very intensive parameter study leads to the following positions of the atoms:

	$P2_1/c$			$B2_1/d$		
atom	x_a	y_b	z_c	X_A	Y_B	Z_C
Fe	−.300	.015	.300	0	.015	.300
Sb	.149	.131	.132	.140	.131	−.008
S	−.356	.145	.667	.156	.145	.511

The interatomic distances found in gudmundite confirm the author's earlier work regarding the abnormal interatomic distances in the members of the marcasite, loellingite, and arsenopyrite groups.

THE ROSEBUD METEORITE, MILAM COUNTY, TEXAS*

FRED M. BULLARD

The Burlington meteorite, received by the University of Texas in 1915, is listed as the Rosebud meteorite in several catalogues but has not been described up to the present time. The specimen, which weighs 54.9 kilograms, is an almost perfect conoid-shaped mass with well developed radial pittings on the front surface. The apex is smooth. In composition the meteorite is of the stony type with slightly more than 13% metallic content. It contains well developed chondrules consisting, for the most part, of olivine and enstatite. A chemical analysis, spectrographic analysis, and a petrographic description were given.

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* Presented through the Geological Society of America.

CRYSTAL SPACE-GROUPS DETERMINED WITHOUT *X*-RAYS

J. D. H. DONNAY

The concepts of *multiple indices*[1] and of the two types of zonal distribution (*simple zones* and *double zones*)[2] are necessary prerequisites for the understanding of the present communication. Orthorhombic crystals only are considered here; similar results are obtained for other systems.

I. Zones of faces that are not perpendicular to possible glide-planes determine the *unit cell* and the *lattice centering.*

II. Zones of faces perpendicular to possible glide-planes indicate the presence or absence of a glide. The character of the axial zones, imposed by the lattice, is modified by *glide-planes:* (1) The dominant face of a simple zone may be shifted towards a pinacoid, as when (012) predominates over (011). The shift indicates the glide direction; e.g., a shift towards the *c* face indicates a *c* glide-plane. This occurs in primitive and one-face centered lattices. (2) A simple zone going into a double zone means an *n* glide-plane (in *P* lattice) or a *d* glide-plane (in *F* lattice). (3) A double zone going into a simple zone means a glide-plane to be lettered by either pinacoid of the zone (in *I* lattice).

In case there is no glide-plane, a pinacoid whose indices are not already doubled by the lattice, may have them doubled by a *screw-axis* (in primitive and one-face centered lattices).

Such simple rules enable one to read directly, from the gnomonic projection, the Mauguin symbol of the space-group (or possible space-groups). Examples: chalcomenite, epsomite, enargite, cerussite, danburite, andalusite, brookite, NH_2SO_3H, carnallite, hemimorphite, natrolite, sulfur.

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[1] *Amer. Min.*, **22** (Palache volume), 446–467, (1937).

[2] *Ann. Soc. géol. Belgique*, **61**, B, 260–287 (1938).

DEHYDRATION AND X-RAY STUDY OF POLLUCITE

MICHAEL FLEISCHER AND C. J. KSANDA

Previous *x*-ray studies of pollucite have led to a suggested crystal structure which is at variance with the chemical composition found by analysis, and with the behavior of the water present in the mineral. Dehydration curves have been obtained for pollucite specimens from Hebron, Maine, and from the island of Elba, and the material has been studied optically and röntgenographically before and after dehydration. The crystal structure, the chemical composition and the role of the water in the mineral were discussed in the light of the new evidence obtained.

PETROLOGY OF THE SHALLOWATER METEORITE

W. F. FOSHAG

The meteorite was found in 1936, near Shallowater, Lubbock County, Texas. It is an extraordinarily coarse diogenite, made up of enstatite 83½%, forsterite 5%, oligoclase ($Ab_{83}An_{17}$) 1½%, nickel-iron and troilite 10%. The silicates are iron free (enstatite 4% FeO). The association of iron free silicates with metallic iron were considered.

CRYSTAL HABIT VARIATION IN SODIUM FLUORIDE

CLIFFORD FRONDEL

An experimental study was made of the effect of foreign materials on the habit of growing crystals of NaF and other NaCl-type alkali halides. Approximately 250 inorganic and organic cosolutes, including 120 dyes, were investigated. The inorganic cosolutes which effect variation from the ordinary (100) habit of NaF fall into two groups:

(1) Cosolutes which afford OH^- ion directly or by hydrolysis, and certain organic cosolutes which contain OH groups cause an octahedral habit. The variation results from the substitutional adsorption (surface isomorphism) of OH^- for F^-, such as shown by Buckley for the adsorption of RO_4 ions by K_2SO_4, $KClO_3$, etc. The variation to octahedra finds explanation in Kossel's and Stranski's analysis of the growth of ionic NaCl-type crystals.

(2) Cosolutes which react chemically to form compounds with NaF cause variation in habit, as found by Retgers and Orloff for other alkali halides. Experimental evidence indicates that the adsorption is not by substitution, but involves the formation of a new, essentially two-dimensional, crystal phase held in ordered apposition to the surface NaF ions. The direction of variation is related to structural coincidences between NaF and crystals of the adsorbed compound. This mechanism illustrates the view of habit variation taken by Bunn.

Extremely few dyes are effective with the alkali halides, in contrast to K_2SO_4, etc., and their action is specific for different halides. The arrangement of polar hydroxyl or sulphonate groups in the dye influences the adsorption. Dye adsorption by neutral, (100), planes is common, contrary to France's theory of adsorption by charged planes.

PERTHITE FROM TORY HILL, ONTARIO

SAMUEL S. GOLDICH AND JAMES H. KINSER

An unusually well-developed perthitic intergrowth of microcline and albite was discovered in pegmatite masses occurring in syenite near Tory Hill, Haliburton County, Ontario. Film and vein perthite are both recognized. In the latter type, the albite is in braid-like veins trending parallel to the trace of the front pinacoid (100). These veins are composed of intertwining blebs of albite which are parallel to the prism faces, (110) and ($1\bar{1}0$), arranged in two superimposed *en echelon* groups forming the braid. Striking features of the intergrowth are the uniformity in orientation and in size of the blebs and the high percentage of albite. Gradations from this regular intergrowth into less regular patterns are believed to be significant in considering some of the theories which have been advanced for the origin of perthites. Petrographic data indicate that the potassic and sodic members of the intergrowth are relatively pure. The composition from a chemical analysis is Ca-f, 0.1; Na-f, 57.7; K-f, 42.2.

METASOMATISM OF A SHALE TO AN IGNEOUS APPEARING ROCK*

G. E. GOODSPEED, RICHARD E. FULLER, AND HOWARD A. COOMBS

During the summer of 1938, a cut in the western extension of the Mount Rainier highway from the southern entrance of the Park at Ohanapecosh disclosed a transition in the metasomatism of a shale. The rock belongs to a series of coal bearing sediments which are exposed along the road for over three miles, and which presumably represent the Puget series of the Eocene. The shale is a dark reddish brown homogeneous rock with fine jointing, and occurs here both in normal beds, and as rounded, angular or irregular blocks ranging from a fraction of an inch to ten feet or more in diameter, enclosed in a light gray rock containing megascopic plagioclase and quartz. Although the contact is locally sharp, it more commonly shows in less than an inch a gradation from the unaltered shale to a rock which by itself would be called a porphyritic dacite and be classed with the Keechelus volcanic series. This transitional facies is marked by the development of feldspathic porphyroblasts in the shale, and by the change of the rock to a pale greenish shade owing to disseminated chlorite. The igneous appearing rock at the contact shows no sign of chilling, while the groundmass locally appears to be indistinguishable from the shale. Some blocks of the shale exhibit fine vein-like extensions of the igneous appearing rock with a coarseness of grain which denotes a crystalloblastic origin. The size and shape of the blocks of the fragile shale preclude a pyroclastic origin and give additional evidence of a metasomatic replacement, in which relics of the shale survive in various stages of transformation.

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* Presented through the Geological Society of America.

THE BEHAVIOR OF SERPENTINES BETWEEN 500° AND 650°C.

JOHN W. GRUNER

In connection with the study of the structure of serpentines, it was shown by Selfridge and the writer that there are two distinct structures which were named antigorites and chrysotiles by them. Contemporaneously Caillère[1] in an extensive study had shown that two types of serpentine (called α and β antigorites by her) exist. Caillère's distinction is based on the different behavior when heated and the appearance of their thermal curves. The writer finds that there is no agreement between the two classifications. A chrysotile may be either an α or β antigorite, or one of the α or β antigorites of Miss Caillère may be an antigorite or chrysotile of the writer.

It was found that all chrysotiles change to olivine (and probably colloidal silica) if held in air at a temperature of 560°C. for 4 to 19 days. The antigorites on the other hand, are not changed so rapidly and some of them seemed to remain serpentine after 34 days as seen by x-rays. In an atmosphere of CO_2 all of them change to olivine at 560°C. within 2 to 22 days. At 650°C. in air even the antigorites change to olivine relatively rapidly. No indication of the formation of enstatite was found at either temperature which is not in agreement with results reported by Caillère.

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[1] Caillère, S., *Bull. Soc. Franc. Min.*, **59**, 163 (1936).

ADSORPTIVE CLAYS OF THE TEXAS GULF COAST

ARTHUR F. HAGNER

Numerous clay pits containing an abundance of material suitable for the clarification and purification of petroleum products are found along the Texas Gulf Coastal Plain. Microscopic, chemical, and *x*-ray examinations indicate that the principal mineral constituent is montmorillonite. Microscopic textures and structures, when well preserved, are significant of origin. Many beds represent the result of alteration in situ of volcanic ash. Substantial amounts of kaolinite, halloysite, and allophane occur in some deposits, indicating variations in origin. The amount of alteration is variable. Some of the original material has altered sufficiently to clay to form fuller's earths of usable quality. In certain deposits alteration has been so complete as to obliterate any definite evidence of origin of the clay.

The waxy character of many moist clay layers has proved of interest. Waxy clays contain more nearly pure montmorillonite than the other types which are soft, granular and kaolinitic. The waxiness may be attributed to the unusual hydration characteristics of montmorillonite. Kaolinitic mixtures occur in the northeastern part of the clay belt, whereas the more nearly pure montmorillonite occurs in the southwestern part. The prevalence of kaolinitic material in the fuller's earths of eastern Texas may account for efficiency ratings below those of the Georgia-Florida fuller's earths.

A review of the literature, correlated with field observations, indicates that the clays of eastern Texas have formed during the Eocene, and Oligocene or Miocene epochs. Correlation of physical, chemical, and optical properties with adsorptive efficiency has been attempted.

CHEMICAL STUDIES OF HEXAHEDRITE METEORITES FROM CHILE

E. P. HENDERSON

A great many of the siderites from Chile belong to the hexahedrite class of meteorites. This suggests that either there has been a shower of this type of material or if these are unrelated falls, then perhaps a chemical study would detect some differences between them. Five new analyses of recently acquired Chilean meteorites (Puripica, Sierra Gorda, Rio Loa, Negrillos, and Coya Norte) are given and compared with each other, as well as with other analyses of this type of meteorite. Between all these Chilean hexahedrites a remarkable agreement was found and if this group alone is considered, it would suggest that all five are from the same fall. However, when these analyses are compared with others of this same classification of meteorites and from widely scattered areas over the world, there still is found the same close agreement, which suggests that this is the fundamental type of material in iron meteorites. Comparing these analyses with those of kamacite, a component in octahedrites, there is also a striking agreement. Henceforth, it certainly seems more logical to consider hexahedrites as meteorites composed entirely of kamacite. Metallographic studies between kamacite and hexahedrites support this conclusion and more detailed studies are being made.

COMPARISON OF THE FABRICS OF XENOLITHS AND THE ADJACENT INTRUSIVE ROCK

EARL INGERSON

Fabric studies of two intrusions and their included xenoliths have been made: (1) The Port Deposit granodiorite in Maryland and (2) the Uncle Sam quartz monzonite porphyry near Tombstone, Arizona. The Port Deposit granodiorite has undergone metamorphism after its intrusion was completed, but the Uncle Sam porphyry is unmetamorphosed. Mica and quartz fabrics of the Port Deposit granodiorite and the xenoliths studied are identical. There is little mica in the Uncle Sam porphyry and none in its xenoliths, which are mostly quartzite. The quartz fabric of the inclusions is unlike that of the porphyry, indicating that the fabric of the inclusions was not produced during intrusion. Presumably, then, the identity of fabric in the Port Deposit granodiorite was produced by metamorphism of the intrusive and its xenoliths after intrusion rather than by working over of the inclusions during intrusion.

MARSHITE FROM CHUQUICAMATA, CHILE

O. W. JARRELL

A few specimens of marshite were recently found in the oxide ore body of the disseminated copper deposit at Chuquicamata, Chile. Its properties agree essentially with the previously described material from Broken Hill, N.S.W. A description of the new occurrence, complete index of refraction determinations, and a new analysis were presented.

AN EXPLANATION OF DIAMOND CUTTING IN TERMS OF ATOMIC STRUCTURE

EDWARD H. KRAUS AND CHESTER B. SLAWSON

Long experience of diamond cutters shows that the hardness of the diamond varies materially with the crystal surface on which the cutting or polishing is done. The hardness is least on planes parallel to faces of the cube. It is greatest on planes parallel to faces of the octahedron, and such planes can be worked only with great difficulty, if at all. The characteristics of diamond dust which make it suitable for sawing and polishing of the diamond were described. The directions in which these processes may be effectively done were indicated in terms of atomic structure. An explanation of the perfect octahedral cleavage was also given.

MINERALS OF EIGHT MILE PARK, COLORADO

KENNETH K. LANDES

Eight Mile Park is the partially wooded upland lying immediately north of Royal Gorge in Fremont County, Colorado. It is floored with crystalline rock of pre-Cambrian age. Granite pegmatites are abundant, and at least three of these have been exploited for feldspar. One deposit, the Mica Hill, has produced more feldspar than any other mine in the state.

The dominant minerals in the Park pegmatites are microcline and quartz. Muscovite is abundant, in some instances occurring in large radiating masses. Beryl crystals with a maximum diameter of two feet are common in the lower part of the Mica Hill open cut. Albite is subordinate. Garnet crystals occur near the margins of some of the pegmatites. An unexploited pegmatite east of Mica Hill contains abundant pink tourmaline and lepidolite. Black tourmaline is found with milky quartz in a hill to the southwest.

In most of these pegmatites the hydrothermal phase was relatively subordinate.

OVERITE, A NEW MINERAL FROM FAIRFIELD, UTAH

ESPER S. LARSEN, 3RD

Overite, $Ca_3Al_6(PO_4)_8 \cdot 20H_2O$, according to a preliminary analysis, is a new mineral from the variscite nodules of Fairfield, Utah. It is orthorhombic and occurs as pale green to colorless prismatic crystals, flattened on (010), in cavities in altered variscite. Cleavage: (010) perfect, (100) poor. $H=4$; $G=2.53$. Biaxial negative, $2V=75° \pm 10°$; $r>v$ weak; $X=c$, $Z=b$. $\alpha=1.568$, $\beta=1.574$, $\gamma=1.580$, all $\pm.002$. Elements (morphological): $a:b:c=0.7839:1:0.3794$. Structural lattice: $a_0=14.62$ Å, $b_0=18.68$ Å, $c_0=7.08$ Å; $a_0:b_0:c_0=0.7827:1:0.3788$; $V_0=1936$ cubic Å. Cell contains $2[Ca_3Al_6(PO_4)_8 \cdot 20H_2O]$.

The mineral is named after Mr. Edwin Over of Colorado Springs, Colorado, who, with Mr. Arthur Montgomery, recognized the mineral as new and collected a sufficient amount for a chemical analysis.

THE SYMMETRY OF PHOSPHOSIDERITE

DUNCAN MC CONNELL

An investigation involving the use of Laue, powder and oscillation methods, as well as etching experiments, demonstrates that phosphosiderite is monoclinic with: $a_0=5.30$, $b_0=9.79$, $c_0=8.67$ Å (all ±0.02 Å) and $a:b:c=0.541:1:0.886$, $\beta=89$–$90°$. This mineral displays pronounced pseudosymmetry which impedes certain measurements. The space group is probably $C_{2h}^2=2\ Ci\text{-}2$. If the unit cell is assumed to contain four molecules of $FePO_4 \cdot 2H_2O$ the theoretical density becomes 2.74, as compared with a recorded value 2.76.

Phosphosiderite is isomorphous with metavariscite only if the latter is pseudosymmetric and, in reality, monoclinic also. Strengite is probably dimorphous with phosphosiderite.

VESUVIANITE FROM GREAT SLAVE LAKE REGION, CANADA

V. BEN MEEN

The crystallographic, optical and chemical properties of well-formed crystals of vesuvianite from this new locality were discussed.

AN ASSOCIATION OF HARMOTOME, CORUNDUM AND HYALOPHANE AT GLEN RIDDLE, PA.

ADOLPH E. MEIER AND W. HAROLD TOMLINSON

In a recent paper an occurrence of harmotome in a basic dike at Glen Riddle, Delaware Co., Pa., was described.* Corundum and potash-barium feldspar were so associated in the rock matrix that a paragenetic relation between all three minerals was indicated. Further study indicates that they were formed at various stages of the same dynamic hydrothermal sequence.

There are two types of hyalophane present, with an orthoclase-celsian content of $Or_{85}Cn_{15}$ and $Or_{90}Cn_{10}$. Both types occur as antiperthites with andesine or oligoclase, or as separate grains in close association with the latter. An occasional perthite occurs in the more alkaline association. Four types of plagioclase are present. The range in anorthite content is from An_{60} to An_{15}. Intermediate types are An_{20} and An_{40}. Spatial relationships of the feldspars are such as to impart to the dike an anorthositic core and a gabbroic rim. Intermediate feldspars, hyalophane and corundum occur mainly along variously spaced crush zones parallel to the foliation in the dike.

The contemporaneous deposition of the hyalophane and corundum and the later deposition of harmotome is considered to be the result of

(1) deformation of a thin dike of anorthositic gabbro, emplaced in pyroxenite, by forces accompanying the intrusion of a hornblende granite close by,

(2) infiltration during or after stress along favorable channels of hydrothermal potash barium solutions emanating from the granite and setting up a series of reactions which resulted in the deposition of mineral suite described.

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* Given at the Eighteenth Annual Meeting of the Min. Soc. of Amer.

LIQUID-VAPOR EQUILIBRIA IN THE SYSTEM K_2O-SiO_2-CO_2-H_2O*

G. W. MOREY AND MICHAEL FLEISCHER

Although there is general agreement that hydrothermal and pneumatolytic processes play important roles in the formation of ore deposits, there is so little physico-chemical data available on the properties of complex solutions at high pressures and temperatures that it is not possible at present to pass upon the validity or competency of the various mechanisms which have been suggested to account for the mode and order of ore deposition. As the first step towards obtaining such data, we have designed an apparatus with which to study the equilibrium distribution of two volatiles between the liquid and vapor phases at high temperatures and pressures. The present paper reports the results obtained in the system K_2O-SiO_2-CO_2-H_2O at 500°C. The effect of changing potash-silica ratios on the distribution of the volatiles is discussed. The change in composition of the vapor phase with diminishing pressure at constant temperature is shown graphically for various initial compositions.

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THE CRYSTALLOGRAPHY OF VEATCHITE

JOSEPH MURDOCH

Some terminated crystals of veatchite, the newly discovered calcium borate from Lang, California, have been measured on the goniometer, and the elements calculated. Using the published values for the unit cell dimensions, the elements are as follows:

$$\begin{array}{lll}
a:b:c=0.163:1:0.998 & & \beta=121°2' \\
p_0:q_0:r_0=6.1227:0.8551:1 & & \mu=\ 58°58' \\
r_2:p_2:q_2=1.1694:7.1599:1 & & \\
p_0'=7.1455 & q_0'=0.998 & x_0'=0.6017
\end{array}$$

The following forms are tentatively recorded: (010) (100) (001) (017) (014) (013) (025) (023) (056) (011) (054) (043) (021) (230) (120) (140) (150) (160) ($\bar{1}66$) ($\bar{1}.7.12$). Of these forms, (010) is always present, well developed, but the clinodome and prism zones are characterized by many narrow and often indeterminate faces, of which the more definite have been selected. Pyramids are rare, only three faces having been found on eight crystals.

INTRODUCTION OF FELDSPAR INTO INCLUSIONS, ELLSWORTH, NEW HAMPSHIRE

LINCOLN R. PAGE

Inclusions of quartz-biotite schist in a porphyritic facies of the Kinsman quartz monzonite, one-half mile east of the north end of Stinson Lake, town of Ellsworth, New Hampshire, show porphyroblasts of soda-feldspar which appear to have been introduced from magmatic sources. These porphyroblasts, up to 6 cm. in length, are similar in appearance to the phenocrysts in the quartz monzonite, but the latter, dominantly microcline feldspar with small amounts of myrmekite, contain few inclusions of the groundmass. The porphyroblasts are present as separate carlsbad twinned crystals and as groups of grains of different optical orientation. Abundant inclusions of the groundmass minerals are present in both occurrences. In some cases these inclusions are scattered throughout individual crystals and in others they are grouped together and surrounded by rims of feldspar up to 5 mm. thick. Replacement textures, inclusions of original minerals within feldspar rims, and mineralogic and field relations strongly suggest that the soda has been added to the quartz-biotite schist from igneous sources.

THE MEASUREMENT OF REFLECTIVITY AND COLOR OF MINERALS

WILLIAM PARRISH

Recently, an attempt has been made to identify opaque minerals by determining their reflectivity by means of auxiliary microscope apparatus such as the Berek slit microphotometer or Orcel photoelectric ocular. In general, measurements obtained with these instruments do not lead to a unique determination of the mineral.

This paper describes a technique for the measurement of the diffuse reflectivity and other data by use of the Hardy recording photoelectric spectrophotometer, which is also known as the color analyzer (*J.O.S.A.*, **28**, 360, 1938). It has the advantages of accuracy to three significant figures, speed, completeness of data, and simplicity of operation; it is applicable to opaque and non-opaque minerals. The chief disadvantage of the instrument is its high cost. It operates automatically and plots a continuous spectrophotometric curve (reflectivity as a function of wavelength) for the entire visible spectrum in about one minute. The specimens may be natural crystal faces or prepared as metallic mirrors, polished surfaces, or powders. The reflectivity curves of about 100 minerals were determined on this instrument and each of these curves is unique.

The Handbook of Colorimetry (M.I.T., 1936) uses three terms to describe color on an absolute color scale: brightness, dominant wavelength, and purity. From the reflectivity curve one can easily calculate these terms and thus describe the precise color of the mineral.

Further experiments are in progress on the determination of the specular reflectivity, with the intention of using this constant to calculate refractive index, absorption, density, and conductivity.

CRYSTALLOGRAPHY OF COPIAPITE

M. A. PEACOCK

On copiapite from Chuquicamata, Chile, Palache obtained the hitherto unpublished triclinic elements:

$$a:b:c=0.4058:1:0.4039;\ \alpha=93°50',\ \beta=102°10',\ \gamma=99°21\tfrac{1}{2}'$$

X-ray photographs, kindly made by Buerger, on a crystal from the same locality, gave the following structural elements in the normal setting:

$$a_0=7.33,\ b_0=18.15,\ c_0=7.27\ \text{Å};\ \alpha=93°51',\ \beta=101°30',\ \gamma=99°23\tfrac{1}{2}'$$
$$a_0:b_0:c_0=0.404:1:0.401$$

On copiapite from Sierra Gorda, Chile, Ungemach (1935) noted 144 forms and obtained elements which, transformed to the normal setting, give:

$$a:b:c=0.4005:1:0.3971;\ \alpha=93°58\tfrac{1}{2}',\ \beta=102°08',\ \gamma=98°50'$$

These variations in the crystallographic elements of copiapite may be explained by the variations in the composition and optics discussed by Berry at this meeting.

In addition to affording a fine example of form development according to the Law of Bravais, a projection of the forms of copiapite presents a striking case of the problem of multiple morphological periods.

NEPHELINE-SYENITE PEGMATITES IN THE BEARPAW MOUNTAINS OF MONTANA

WILLIAM T. PECORA

In the western Bearpaw Mountains of Montana is situated a composite stock of Tertiary age, made up chiefly of pyroxenite, shonkinite, syenite and nepheline syenite. The pegmatites described are intimately associated with the nepheline syenite bodies as late segregations, or with the adjacent older rocks as dike injections. The deposits are numerous, varying in width up to six feet and in length of outcrop up to a few hundred feet.

The primary minerals present are feldspar, nepheline, biotite, and garnet (melanite). Replacement minerals include sphene, ilmenite, fibrous and prismatic aegirine, eudyalite, lamprophyllite, and occasional metallic sulfides. Tabulations and discussions of chemical analyses and optical properties are also included. The mineral associations of these hitherto undescribed pegmatites are similar to those of other better-known localities, such as the Kola Peninsula.

A MINERALOGICAL TRIP TO EUROPE

AUSTIN F. ROGERS

An account of collecting trips to Mill Close, Castleton, Llandudno, Saltbura, Fallowfield, Cornwall, Moresnet, Ytterby, Langban, Oslo, Snarum, Kongsberg, Langesund, Kragerö, Erje, Iveland, and Saalfeld.

An account of visits to establishments at Antwerp and Idar-Oberstein and to the museums and mineralogical institutes of London, Oxford, Cambridge, Edinburgh, Camborne, Brussels, Ghent, Louvain, Liège, Amsterdam, Leiden, Groningen, Copenhagen, Oslo, Stockholm, Upsala, Berlin, Zurich and Paris.

MONTICELLITE ROCK FROM CRESTMORE, CALIFORNIA

AUSTIN F. ROGERS

For many years the rare mineral monticellite (a double salt with the formula: $CaMgSiO_4$) was known from only one locality in this country (Magnet Cove, Arkansas).

In 1917 Eakle described it from the contact-metamorphic zone of Crestmore, where he found it with xanthophyllite in blue calcite. More recently Moehlman and Gonyer describe it as a minor constituent of a metamorphic silicate complex from Crestmore.

Crestmore probably ranks as the most prominent locality for monticellite, for the writer about a decade ago found it here in huge blocks in the "Wet Weather" quarry.

The monticellite rock is a pale brown medium-grained granulose massive rock with green spots of idocrase. The idocrase apparently replaces the monticellite and it seems likely that at least some of the massive idocrase at this locality is a replacement of the monticellite rock.

PRELIMINARY REPORT ON THE SYSTEM, FeO-Al_2O_3-SiO_2

J. F. SCHAIRER

In order to obtain more information on the compositions and stability relations of the FeO-bearing pyroxenes, it will be necessary to obtain silicate equilibrium data for quaternary systems involving CaO-FeO-Al_2O_3-SiO_2 and MgO-FeO-Al_2O_3-SiO_2. Before beginning determinations on these quaternary systems it is necessary to know the relations in the system, FeO-Al_2O_3-SiO_2.

The system, FeO-Al_2O_3-SiO_2, is under investigation and substantial progress has been made in determining the liquidus surfaces of the several solid phases. Tridymite, cristobalite, spinel (hercynite), fayalite, mullite, and corundum liquidus surfaces have been determined in whole or in part. One eutectic and two reaction points have been located. So far no ternary compounds have been encountered at the liquidus temperatures.

RHYODACITE FROM THE TRANQUILLE PLATEAU, BRITISH COLUMBIA

LOUISE STEVENS STEVENSON

Siliceous lavas are very uncommon in the Tertiary volcanics of the British Columbia interior plateaus, and the present paper records what is believed to be the first such occurrence to be studied in petrographic detail. A plug-like outcrop of white, fine grained, porphyritic rock was found in the upper Tranquille valley in a group of middle-Tertiary lavas. It has been identified microscopically as a rhyodacite, corresponding to 237E of Johannsen's classification. Phenocrysts of oligoclase, quartz, sanidine, and biotite are embedded in a microcrystalline groundmass. Results of optical study of the minerals, and of Rosiwal determinations, were given.

TWINNED OCTAHEDRA OF FLUORITE AND ASSOCIATED MINERALS FROM MT. ANTERO

GEORGE SWITZER

During the summer of 1938 a study was made of the pegmatites of the Mt. Antero region, in company with Mr. Arthur Montgomery and Mr. Edwin Over.

Fluorite crystals were found twinned by the usual law but showing only, or dominantly, the octahedron form, a new habit for this mineral.

The fluorite-bearing pegmatites may be grouped in five different types. The paragenesis of each type was described and the habit-association relationships of some of the minerals pointed out. The minerals occurring in the pegmatites are feldspar, quartz, muscovite, beryl, phenakite, topaz, bertrandite, fluorite, limonite, and sulphur.

THE CORUNDUM IN THE GLEN RIDDLE DIKE

W. HAROLD TOMLINSON

Discussion of corundum pegmatites and their connection with gabbro differentiates. Connection shown between corundum pegmatites and granite volatiles. Description given of corundum dike and associated rocks at Glen Riddle. Two reactions illustrated by which corundum is formed from excess alumina liberated from anorthite when attacked by volatile elements. A theory contending that all alumina available for corundum was carried in magma as anorthite and that corundum was formed by reaction between anorthite and volatile elements. This reaction at near magma temperatures. Application of this theory to some corundum localities.

POTASSIUM TETRATHIONATE AS AN EXAMPLE OF MONOCLINIC HEMIHEDRAL SYMMETRY

G. TUNELL, H. E. MERWIN, AND C. J. KSANDA

Crystals of potassium tetrathionate and potassium pentathionate were synthesized and analyzed by Dr. E. T. Allen in connection with an investigation of the volcanic activity and hot springs of Lassen Peak, where pentathionate was proved to be present in some of the fumarolic products; tetrathionate was not proved to be present and could not have exceeded a few tenths of one per cent in the samples examined from Lassen Peak, if it occurred in them at all. The crystallographic properties of the potassium tetrathionate were determined in the present study, also its space-group. Potassium tetrathionate is notable for its pronounced monoclinic hemihedrism, and was found by Messrs. Hendricks and Jefferson to have an unusually strong pyroelectric effect.

AN OCCURRENCE OF CHRYSOBERYL NEAR GOLDEN, COLORADO

W. A. WALDSCHMIDT AND R. V. GAINES

Chrysoberyl, found near Drew Hill, about ten miles from Golden, Colorado, occurs in a small granite pegmatite dike. The crystals and crystalline masses of chrysoberyl from this locality are exceptionally large. One tabular mass weighs slightly over two pounds. The largest single crystal found measures 11/16 inch in thickness, 1-9/16 inches in width, and 3-3/4 inches in length. All of the specimens of chrysoberyl thus far found in place are near the center of the dike in close association with massive quartz or quartz-muscovite segregations.

LARGE SPHENE CRYSTALS FROM SAN JACINTO MOUNTAINS, CALIFORNIA

ROBERT W. WEBB

Large sphene crystals disseminated in plutonic rocks are not commonly found. Recently an area in the batholith of the San Jacinto Mountains, Riverside County, California, has been found in which a microcline quartz-diorite contains crystals of sphene which are abundant in sizes up to 1″×½″×½″. The crystals are perfectly formed euhedrons, occurring separately and in groups. Thousands of crystals of good size are obtainable without difficulty from the decomposed rock. Microscopic examination shows the crystals to include subhedral grains of andesine and anhedrons of quartz. These relations and other features of the sphene indicate a late or secondary introduction of the sphene crystals.

MINERAL COMPOSITION OF HAWAIIAN CERAMIC CLAY

CHESTER K. WENTWORTH, ROGER C. WELLS, AND VICTOR T. ALLEN

Since 1935 small amounts of medium or light gray residual clay of ceramic quality have been found in restricted upland areas on Oahu, Maui, Molokai, and Kauai. The deposits take the form of thin underclays, always overlain by a well marked humus or peat layer at the modern surface, and usually underlain by thin but more or less continuous masses of iron pan followed by weathered, buff or brown residuum.

In every instance the clay occurs in sloping areas of little relief, remnants of original constructional surfaces of volcanic domes, which receive rainfall of 150 to 400 inches annually but have long remained free from significant disturbance by erosion or deposition. In elevations ranging from 2500 to 5500 feet, patches of more or less distinctive bog vegetation have developed and are apparently the basis of the reducing conditions under which a clay fairly low in iron has been produced.

Three complete chemical analyses show a rather variable composition, silica 34 to 57 per cent, alumina 22 to 26 per cent, iron oxides 3 to 9 per cent. Most surprising is over 14 per cent of titanium oxide in two of the samples. Preliminary petrographic studies indicate the derivation of the clay from basaltic lavas, the feldspar phenocrysts changing to kaolinite and the matrix, originally feldspars and ferromagnesian minerals, to illite. Elutriation concentrates from the clay contain plagioclase, ilmenite, and leucoxene. The latter minerals probably account for the high titanium which was derived from original ilmenite and titaniferous augite.

OPTIC PROPERTIES OF ORGANIC AND INORGANIC COMPOUNDS COMPARED

A. N. WINCHELL

A diagram has been prepared showing the optic properties of about 1000 organic compounds (including all those that have been measured). Such a diagram can be used for the rapid identification of any unknown compound which has been placed on it. By comparison with a similar diagram of optic properties of inorganic compounds it appears that organic compounds show considerably greater variation than the inorganic, both in refringence and in birefringence.

SYMMETRY AND UNIT CELL OF HOPEITE

C. W. WOLFE

X-ray examination of hopeite gave the following cell lengths: $a_0=10.64$ Å, $b_0=18.32$ Å, $c_0=5.03$ Å; $a_0:b_0:c_0=0.5808:1:0.2745$; $M_0=1833.0=4[Zn_3(PO_4)_2\cdot 4H_2O]$. In Spencer's work on this mineral where it was considered to be holohedral, the above axial relations may be expressed as $b:3a:c$. Ungemach later recognized the proper lengths, but thinking that hopeite represented a 33rd crystal class, that is, orthorhombic with but one plane of symmetry, he changed the setting to make this plane basal. The transformations from the Spencer setting and from Ungemach's setting to the structural one are respectively: 010/300/001 and 010/001/100.

A study of the spectral omissions plus consideration of symmetry limitations noted by Spencer, Ungemach, and the author (on new crystals) definitely fixes the symmetry of hopeite to be bisphenoidal with the space group $D_2^4 - P\,2_12_12_1$. The one, two, or three planes of symmetry commonly observed on hopeite are due to twinning, two of these twin laws having been demonstrated by earlier workers and the third, postulated by the author.

It is estimated that more than 250 attended the various sessions of the Society. Among those who registered were:

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1923 Washington, D.C.
1924 Ithaca, New York
1925 New Haven, Connecticut
1926 Madison, Wisconsin
1927 Cleveland, Ohio
1928 New York, N.Y.
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1930 Toronto, Canada
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Glavogneupor, Pokrovskij Buljvar 14, Moscow, U.S.S.R.
Gl. Red. Gorno Topl. Literatury, Pr. Vladimirowa 4, Moscow, U.S.S.R.
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Moskovsky Geologo-Razvedotschny Institut, Biblioteke, Mokhovaja II, Moscow, U.S.S.R.
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Biblioteke Uraljskogo Nauchno Issledov. In Tuta Geolog. Rasve, Dok I. Issled Miner Syrja Uralgeomin Pervomajskaja 1, Sverdlovsk, U.S.S.R.
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PROCEEDINGS OF SOCIETIES

NEW YORK MINERALOGICAL CLUB

American Museum of Natural History, New York City, October 19, 1938

The first meeting of the fall season opened with a resumé of the past year's accomplishments. About 78 members and guests were present; Dr. Olaf Andersen presided.

As is the custom at the first meeting, the program was then turned over to the members who recounted their summer collecting experiences and displayed specimens. Miss Catherine Schroeder told of a submarine phosphate deposit near San Diego, California. O. I. Lee spoke of a trip to the North Carolina pegmatites, where this year he collected sphene crystals of gem quality and a terminated green tourmaline crystal. M. A. Northup described collecting in the Pennsylvania coal region, where he found in the slates and mine waste, pyrite, millerite crystal tufts, siderite, ankerite, barite, quartz and pyrophyllite.

L. N. Yedlin displayed some Paterson minerals, and massive scheelite in hornblende schist from Trumbull, Connecticut. Harry Grahl showed additional Paterson minerals, stilbite from Summit, N. J.; and stilbite, heulandite, pyrite, and sphaerosiderite from the new Queens Tunnel dump in Flushing Bay. J. A. Taylor had minute modified fluorite crystals from a quarry near the Empire City racetrack. Peter Zodac exhibited dumortierite and molybdenite from shaft 18 of the new water tunnel at Valhalla. A. C. Hawkins showed long needle-like gypsum crystals from New Mexico.

F. H. Pough, *Secretary*

American Museum of Natural History, New York City, November 16, 1938

The meeting was called to order by President Andersen with about 60 members and guests present. L. N. Yedlin, as Chairman of the Excursion Committee, reported a very successful trip on October 30 to the Vandermeed Quarry in Paterson, where all of the members secured fine specimens of zeolites and associated minerals. The speaker of the evening, Dr. E. G. Zies, then addressed the Club upon "Mineral Products of Volcanic Activity."

The speaker brought out a number of interesting features in connection with their study of the Valley of Ten Thousand Smokes, especially regarding the abnormal composition of the magnetite crystals found only in the fumarole vents in the rhyolitic extrusion on the floor of the valley. They contain Pb, Zn, and Cu in considerable quantity. A later visit after temperature had fallen showed them to have decomposed with the formation of PbS, ZnS, and CuS. The mineralogical implications of the talk, the potentialities of vapor activity in forming concentrations of valuable elements until a deposit of economic value has been developed, were of as much interest and as novel to many of the members as the knowledge of mineral paragenesis. Dr. Zies also described volcanic activity in Central America and in the Pacific islands and illustrated the talk with fine lantern slides and unusual specimens.

An extra meeting of the Club was held on December 1, attended by about 30 members, at which a symposium on the occurrence of prehnite was given. Members displayed specimens from their collections and told many interesting facts about the mineral and their experiences in collecting it. This type of meeting, without a formal program to discuss one or more minerals, was found to be very successful and popular with those who attended, and more are planned for the coming year.

F. H. POUGH, *Secretary*

American Museum of Natural History, New York City, December 21, 1938

The meeting was called to order by President Andersen with about 65 members and guests present. The speaker of the evening, Mr. Arthur Montgomery, a fellow member, was then presented and spoke upon his summer experiences "Collecting on Mt. Antero." He and his partner Edwin Over, first searched for the old Sterling, Colorado, barite locality, while waiting for the weather conditions in the mountains to improve. Finally finding it some miles west of Sterling, in a small canyon, they were successful in obtaining some very attractive specimens. Loose crystals were found upon the slopes and upon digging into the soft weathered volcanic tuff they were fortunate enough to locate several crystal-filled pockets. The lovely pale blue color was well shown in these specimens, and in others which were collected from a calcite vein in which the crystals were all coated with an easily removable crust of calcite. After two weeks in this locality they returned to the mountains and despite adverse conditions decided to explore the slopes of Mt. Antero and White Mountain. Here, dividing their efforts, Over concentrated on White Mountain and found a few aquamarine pockets, while Montgomery worked on Antero. The most interesting and unexpected find of the summer was made by Montgomery when two pockets were uncovered with octahedral fluorite crystals twinned in the spinel manner. A good many pockets were found, in spite of the many years of collecting on Antero, and the largest phenakites from this locality were collected. The bertrandite was disappointing. The talk was illustrated with natural color photographs and fine lantern slides, which showed well the beauty of the region in which they were working.

When the meeting adjourned the members examined the specimens which Mr. Montgomery exhibited.

F. H. POUGH, *Secretary*

PHILADELPHIA MINERALOGICAL SOCIETY

Academy of Natural Sciences, Philadelphia, Pa.

A stated meeting of the Philadelphia Mineralogical Society was called to order on November 3rd, 1938, by the president, Mr. Harry Trudell.

Messrs. Ralph Hoffa and Frank Bozzelli discussed the cutting and polishing of minerals and gems. The first speaker, Mr. Hoffa, described the technique used in cutting flat and cabochon gems, spheres, and decorative inlaid boxes. The second speaker, Mr. Bozzelli, described the facetting of gems. He pointed out the peculiarities of certain gem minerals and the precautions to be exercised in cutting them. Both speakers exhibited samples of their work.

Mr. Trudell reported on the first meeting of the Philadelphia Geological Society and Mr. Moyd gave a summary of the New England Geologist's Field Conference, which met at Rutland, Vt.

Louis Moyd, *Secretary*

Academy of Natural Sciences, Philadelphia, Pa.

Mr. Harry Trudell presided at a meeting of the Philadelphia Mineralogical Society held on December 1st, 1938.

The subject of the evening was a symposium on the lead, zinc and copper mines near Phoenixville, Pa. The first speaker, Mr. Toothaker, described the Wheatley Mine in operation, when he first visited it in 1895. At that time the ore was a fine-grained, argentiferous galena, the silver content of which was high enough to pay for the mining costs of the ore. High cost of pumping soon made mining unprofitable. Mr. Arndt described the geology of the lodes, which are true fissure veins cutting the Baltimore gneiss, Pickering gneiss, and Stockton shale. Their age is determined as late or post-Triassic as they cut Triassic diabase dikes. Downward percolation has greatly affected the veins, producing the secondary minerals cerussite, anglesite, and pyromorphite. Mr. Roedder described the present condition of the mines, all of which are inactive, and the mineral collecting possibilities still available to those who wish to dig in the dumps. Many members recalled interesting personal experiences during visits to the mines over a long period of years. Attractive specimens collected at the mines were displayed.

Mr. Vanartsdalen exhibited a specimen of polished blue quartz from Bucks Co., Pa., and a discussion followed as to the possible cause of the color. Dr. Berliner exhibited a large model of a diamond cut from a colorless plastic.

Louis Moyd, *Secretary*

TEACHING FELLOWSHIP IN MINERALOGY

A teaching fellowship in mineralogy at Stanford University is now open to properly qualified graduate students who intend to specialize in mineralogy. Preference will be given to those who have had two years of graduate work. The chief duty of the fellow is to assist in laboratory instruction. Not more than eight or nine hours a week will be required. The amount of the fellowship is $750.

Application for the year 1939–40, accompanied by a photograph of the candidate and supported by testimonial letters, should be made to Professor Austin F. Rogers, Box 87, Stanford University, California.